[UNIVERSITY OF LONDON]

WYE COLLEGE

Department of Hop Research

ANNUAL REPORT

1952

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DEPARTMENTAL STAFF

Head of Department

*A. H. Burgess, B.Sc.(Agric.), D.Sc.

Hop Breeding and Genetics

†S. O. S. Dark, B.Sc., Ph.D.

Professor E. S. Salmon, F.L.S., Fellow of Wye College
(Acting in honorary capacity)

Chemistry

F. C. Thompson, B.Sc., M.Sc.(Agric. Chem.), A.R.I.C.

E. G. Cripps, B.Sc.(Agric.), A.I.C.T.A.

†A. R. Tatchell, M.Sc., A.R.I.C.

G. A. Watson, M.Sc.(Agric. Chem.), A.R.C.S., A.R.I.C., D.I.C.

Field Section

F. H. Beard, Dip. Hortic.(Wye)

R. F. Farrar

* Retired on 31st December, 1952.
† Resigned in September, 1952.

DEPARTMENT OF HOP RESEARCH

Introduction

It is with the very greatest regret that the College has to report the retirement, at the end of December, of Dr. A. H. Burgess from the position of Head of the Hop Research Department. Dr. Burgess's association with the College goes back a long way; he graduated as a student in 1914 and returned to the College, after war service, in 1919 as an assistant in the Department of Chemistry. In 1920 the Institute of Brewing inaugurated its Research Scheme and soon afterwards the Institute made a grant to the College to enable it to carry out research work on the manuring and drying of hops and on the analysis of new hops which were being raised by Professor Salmon. This work was put under the general direction of Dr. Burgess. In 1929 the College Hop Research Department was formed, being financed from a grant from the funds of the 1914-1918 Hop Control, and Dr. Burgess was put in charge of the Department. During the late war Dr. Burgess was seconded to the Kent War Agricultural Committee and on the re-opening of the College in 1945 he returned to the Department of Hop Research to reorganize it. During the past seven years at the College he has been responsible for the direction of the Department and for its expanded programme of work.

Dr. Burgess has an unrivalled knowledge of all facets of the husbandry of the hop crop. Under his extremely able guidance the College has built up an international reputation for its work on hop growing and there can be few hop growers to whom Dr. Burgess is not both well known and regarded as a personal friend. Much of the success of the work which he developed at Wye has depended upon the close personal relationship which he has built up between the College, the growers, and the Brewing Industry. Although the College has sustained a great loss by his retirement, his services will not be lost to the Industry since he has taken up private consultative work.

The College also has to report, with regret, the resignation of Dr. S. O. S. Dark, who left the Department at the end of September to take up work on cotton breeding with the Empire Cotton Growing Corporation in the Sudan. Mr. A. R. Tatchell also resigned at the same time as Dr. Dark to continue his work on the constituents of

the hop cone at the Brewing Industry Research Foundation at Nutfield.

Although the Department must suffer from the resignations reported above it is hoped that successors will be found to fill the vacancies, and every effort is being made to see that the routine work of the Department will be as little interrupted as possible. Work has already started on the extension of the oast at Coldharbour Farm, which will greatly facilitate the handling of the increasing quantity of hops from the experimental plots and extensions to the new Research Laboratory should be completed by the end of the summer.

The College again desires to express its appreciation of the co-operation it continues to receive from the growers, Hops Marketing Board, the Brewing Industry Research Foundation and from its colleagues at the East Malling Research Station.

DUNSTAN SKILBECK,
Principal.

GENERAL REPORT

THE HOP GARDENS

Weather conditions in April and May were unusually favourable for growth and the hops were very forward at the time of training; growth continued to be vigorous during the hot dry months of June and July in Wye Field and Silks hop gardens but the Nursery garden suffered somewhat from drought. Cool, wet weather in August delayed ripening of cones produced from late burr; this caused the crop to mature unevenly which made drying rather more difficult.

Large numbers of Downy Mildew spikes were produced during April, May and June; these were promptly removed and this, combined with Bordeaux spraying, kept the disease in check. Hop Mould was first noticed on some young shoots in mid-April and, in spite of frequent dusting with sulphur, continued to survive here and there in the gardens. Aphis and Red Spider were completely controlled by spraying with T.E.P.P. and a systemic insecticide. Two plants of Bullion and Brewer's Gold hops, in Wye Field, were killed by Phytophthora Root-rot and four cases of Mosaic Disease occurred among the Goldings in Silks garden.

The hop-pickers were organized as one party, instead of two as in previous years. This new arrangement was successful; it saved labour and simplified management. Picking lasted for five weeks due to the large crop and restricted drying facilities; it will be most important to have the extension of the oast-house completed in time for next year's crop, which will possibly exceed that of 1952. All the hops were harvested in ripe and healthy condition; the total yield was 344 cwt. (108 cwt. more than in 1951 owing to the excellent crop from the new plantings in Wye Field).

Wye Field Hop Garden

(*a*) *Height of Wirework and Spacing Trial*

This trial comprises three heights of wirework—13 ft., 15 ft. and 17 ft. 3 in.—combined with three different spacings—6 ft.$\times 6\frac{1}{2}$ ft.; $7\frac{1}{2}$ ft.$\times 6\frac{1}{2}$ ft.; and 9 ft.$\times 6\frac{1}{2}$ ft.; and is carried out on four varieties of hops—Fuggle; John Ford; Bullion, and Brewer's Gold. All the

hops made good growth, but the Fuggles and John Ford hops, which had been planted as layered cuttings in 1951, needed a certain amount of gapping up so were not sufficiently uniform to justify taking records of yields; the Bullion and Brewer's Gold, however, which were planted as bedded sets were well established and the weights of green hops were recorded from the plots of these varieties.

TABLE 1
WYE FIELD VARIETY PLOTS 1952.

Plots	Variety	Date picked	Hills	Bush.	Dry Wt. lb.	Yield cwt. per acre	Bush./cwt.	
1	WFI36	Sept. 16	41	79½	82	21·60	109	
2	WFA90	Sept. 4	40	62½	149	19·63	102	John Ford Hop
36	,,	,,	42	73½				
5	WFG19	Sept. 4	40	72½				Norton Court Golding
11	,,	,,	40	65	217	19·87	112	
45	,,	,,	38	79½				
8	OQ14	Sept. 16	42	61½	70	18·01	98	
9	WFB135	Sept. 4	40	53½	125	16·88	100	Northern Brewer
16	,,	,,	40	56				
12	WFF12	Aug. 19	40	40	48	12·96	93	
14	WFI94	Sept. 4	40	52	134	16·08	99	
49	,,	,,	50	66½				
15	WFD20	Sept. 4	40	63½	136	16·70	105	
28	,,	,,	48	64¼				
17	WFC81	Sept. 16	40	52	62	16·75	94	Wye Field Golding
18	WFA53	Sept. 4	40	67	66	17·83	112	
21	OH77	Sept. 15	44	84½	97	23·82	98	
25	WFF90	Sept. 16	—	25	31		90	(Young plants)
30	WFF133	Sept. 4	40	46½	54	14·58	96	
32	WFD88	Sept. 4	40	60½	67	18·10	101	
34	WFH16	Aug. 19	40	45	59	15·94	85	
35	OT48	Sept. 4	48	46½	63	14·18	83	(Young plants) Bramling Cross
37	WFI66	Sept. 16	40	62½	74	19·99	95	
39	WFB117	Sept. 16	40	63½	72	19·45	99	
41	WFD82	Sept. 15	40	60	75	20·26	90	
42	WFD81	Sept. 4	48	60½	81	18·23	84	
44	WFJ53	Sept. 16	40	81	95	25·65	96	
60	WFF93	Sept. 4	39	45½	57	15·79	89	
61	WFH65	Sept. 16	40	85½	94	25·39	102	
62	ADD50	Sept. 16	40	94½	90	24·33	118	
63	OD18	Sept. 16	60	145	149	26·83	109	
64	OR38	Sept. 17	39	71	76	21·05	105	
67	OT9	Sept. 17	40	74½	83	22·42	101	
75	OL53	Sept. 17	40	87	87	23·50	112	
76	R1/38a	Sept. 16	40	68	95	25·65	80	

The highest yield per acre of Bullion Hop was produced on the 15 ft. high wirework with the plants spaced $6 \times 6\frac{1}{2}$ ft.; the highest yield of Brewer's Gold was also produced on the 15 ft. high wirework but the spacing in this case was $7\frac{1}{2} \times 6\frac{1}{2}$ ft. The wider the spacing the greater was the yield per hill but this did not compensate for the fewer hills per acre in the widest planted hops ($9 \times 6\frac{1}{2}$ ft.). These results are, of course, only tentative as the plants are not yet fully established and, furthermore, several years' results are necessary before any definite conclusions can be drawn.

(*b*) *Fuggle Clones*

Observations were made on the clonal plants of the 39 selected Fuggle types. The plants are not yet mature and suffered from drought, so it is not possible to draw other than tentative conclusions but some of them appeared to be definitely more vigorous and to yield better than others.

(*c*) *New Variety Plots*

The crops from 29 varieties were picked and dried separately, giving information on yield and bushel/cwt. ratio and providing material for market valuation and brewing trials. The results are given in Table 1.

Records have been taken of the incidence of Downy Mildew and Mould on these plots.

(*d*) *Wye Field Nursery* (see "Nursery Garden")

Silks Garden

The plants again grew vigorously in this garden. For the first time since planting in 1949 there was a severe outbreak of Downy Mildew; the Early Birds had far fewer "spikes" than the Petham and Eastwell Goldings, but the infection of lateral branches was practically uniform throughout the three varieties.

Records have been taken and the yields weighed from the plots in the experiment on cutting bines at picking time and leaf stripping. Growth was again vigorous on all the plots and, as in 1951, there was no significant difference in yield from any of the treatments.

Observations have been made on the characters of the collection of clonal Goldings, to which four clones of the Mathon variety have been added this year. Samples from the parent plants have been analysed for resin content.

Further data has been collected on the flowering periods of the collection of mosaic-susceptible male hops in this garden.

Nursery Garden

Notes have been made on the several thousand seedling hops in the Nursery Garden and in Wye Field Nursery and the routine work of grubbing worthless plants and replacing with new seedlings has been continued.

Samples of cones from 42 seedling plants which appeared to show promise were collected and analysed for resin content; the percentage of soft resins ranged from 22 per cent. to 10 per cent. and the alpha fraction from 9·4 per cent. to 1 per cent. Box samples have been prepared for submission to a brewer and firm of hop merchants for their opinion on the hops.

The hops from 15 variety plots in this garden were picked and dried separately for commercial valuation and brewing trial.

This garden suffered from the drought in July, consequently the crop was somewhat lower than last year.

Out-station Variety Trial

A trial of six new varieties—Early Choice; College Cluster; Pride of Kent; John Ford; Malling Mid-season; and Northern Brewer —80 hills of each, has been planted on a farm in the Fuggle-growing district of the Weald. In spite of rather poor planting material the take was good and little gapping-up will be required.

PLANT BREEDING

Verticillium Wilt Resistance

The second season's work on the *Verticillium* Wilt resistance breeding project, in co-operation with East Malling Research Station, has been completed. Of the 3,000 seedling plants raised from crosses made with *Verticillium* Wilt resistant males, approximately 1,000 were discarded for weakness or susceptibility to Downy Mildew disease. The remaining 1,960 were propagated; 13,617 cuttings from these were planted in 1952 and the parent plants sent to East Malling Research Station, where they were submitted to a severe infection with *Verticillium* Wilt. A very high proportion of the plants were found by these tests at East Malling to resist the disease and the best of these as judged by the aroma of the ripe cones, richness in resins and general cultural characters, some 245 varieties, were selected to undergo an extended test for resistance to *Verticillium* Wilt at East Malling; the sets raised at Wye being used for this purpose. The sets from the 1,715 varieties

which were found to be susceptible to Wilt, or unsuitable for other reasons, have been discarded.

Crosses were made of Nonsuch (the hop with the highest resistance to *Verticillium* Wilt) with four resistant males, in order to produce even more highly resistant types, particularly males, for use in further breeding work.

Polyploid Hops

Further work was carried out on the problem of developing tetraploid forms of Eastwell and Petham Goldings, Fuggle, Bullion, Brewer's Gold, Wye Field Golding and Nonsuch to use in the breeding of improved triploid hops. Some plants were isolated which gave good yields of triploid offspring and further tests are in progress. Results will not be available until seedlings can be raised and examined in the spring of 1953. Two families of triploid plants derived by open pollination of tetraploid Bullion and Brewer's Gold hops, have been planted out in the experimental garden. The plants which have cropped this year have successfully demonstrated (1) that these seedling plants bear cones closely resembling the original diploid variety in form, and in some cases resin content and aroma, and (2) that under conditions of pollination which gave full seeding of the control plants of Bullion and Brewer's Gold, these triploids produced fully grown out hops which were practically seedless. The production of these triploid hops with characters resembling the original diploid has bearings in two important directions; in the first place it may enable us to introduce hops bearing characters similar to existing varieties which, although fully pollinated, will be practically seedless and yet will produce fully developed cones and, secondly, it gives us reason to hope that, in the future, it may be possible to introduce desirable new characters, such as resistance to specific diseases, into a triploid plant having other characters resembling its diploid ancestor, except that it will be seedless.

Resin Glands on Foliage Leaves and Anthers

A final series of samples has been taken this season to make a comparison between all the plants which have been used in the experiment which in previous seasons has shown (1) that the concentration of resin glands on the leaves decreases from bottom to top of the bine, and (2) that there is no correlation between the richness of resins in the cones and the number of resin glands per

square cm. on the leaves of the same plant, or between the corresponding mean values for different varieties of hops.

The survey of the number of resin glands occurring in the anther furrow of all available male hops has been continued. Samples have also been collected for an experiment to analyse the variance of this character. If any correlation is found it will be of value in selecting male hops for breeding purposes.

Homozygous Golden-leaved Male Hop

The backcross plants have now flowered in the experiment designed to produce homozygous golden-leaved male plants for use in genetical and physiological experiments. Only one male plant appeared in three families containing 33 female plants. Further families would have to be raised to investigate the causes of this strange sex ratio. Next year it is hoped to test the solitary male for homozygosity, though its extreme lateness in flowering will make this difficult.

Characters of Wild American Hops

Two pure bred families of wild hops have now been raised. Seedling and young plant characters for the *neomexicanus* family have been observed, but the cold wet autumn weather has prevented proper ripening of the cones, which develop late in our climate. The Canadian wild family has just completed its seedling season, and two plants cropped heavily enough to produce a sample of cones for P.V. determination.

COMMERCIAL GROWTH OF NEW VARIETIES

The production of new varieties which have been introduced commercially continues to increase from year to year. The following information as to (1) the crop marketed by Registered Producers in 1952 and (2) the acreage in June, 1952, of these varieties, has been supplied by the Hops Marketing Board.

Crop		
1951	5,564 pockets	approx. 8,346 cwt.
1952	6,083 ,,	,, 9,124 ,,

The 6,083 pockets marketed in 1952 consisted mainly of Brewer's Gold (C9*a*), 1,816 pockets; Keyworth's Midseason (OR55), 1,753 pockets; Bullion Hop (Q43), 849 pockets; Early Promise

(X35), 694 pockets; Keyworth's Early (OJ47), 187 pockets; Northern Brewer (WFB135), 119 pockets; Malling Midseason (BB28), 77 pockets; and Pride of Kent (170*a*), 72 pockets. Small amounts of the following varieties were grown: John Ford Hop (WFA90); Quality Hop (OO63); Concord (OH44); Sunshine (V94); College Cluster (N15 *bis*); Brewer's Stand-by (HH44); and Early Choice (FF21).

Acreage

Variety	*Acres*
Keyworth's Midseason (OR55)	307·1
Brewer's Gold (C9*a*)	221·0
Bullion Hop (Q43)	101·1
Early Promise (X35)	93·1
Unspecified varieties	84·2
Keyworth's Early (OJ47)	67·1
Northern Brewer (WFB135)	25·4
Pride of Kent (170*a*)	12·0
Brewer's Stand-by (HH44)	9·3
John Ford Hop (WFA90)	8·5
Quality Hop (OO63)	8·4
Early Choice (FF21)	6·0
Concord (OH44)	5·1
Sunshine (V94)	4·7
Malling Midseason (BB28)	2·7
College Cluster (N15 *bis*)	2·4
C2 (E.M.R.S.)	1·6
Bramling Cross (OT48)	1·5
Brewer's Favourite (OP21)	1·4
Norton Court Golding (WFG19)	0·7
AGG8	0·5
D1 (E.M.R.S.)	0·5
OF27	0·4
CC31	0·2
WFF12	0·1
WFB10	0·1
WFF28	0·1
ON78	0·1
	965·9

It is not possible to assess the yields per acre from the above figures, owing to the fact that some of the acreage consists of young,

newly planted hops and also where a grower has only a very small acreage of a variety it is not always harvested separately.

Prof. E. S. Salmon reports that numerous applications were received for rooted sets of the *Verticillium* Wilt resistant variety "Bramling Cross" (OT48). (See this Report for 1951, p. 78.) The "rationed" number of 25 sets were supplied to thirty-six growers whose gardens are attacked by this disease; it has been reported that in some of these cases the growing of the Fuggle variety "is no longer an economic proposition". Many of the growers supplied intend to propagate the variety by layering. Two nurserymen outside the county have received foundation stock.

Propagation has been carried out of twelve new seedlings, of varied parentage considered likely to give resistance to the Wilt; thirty rooted sets of each have been supplied to East Malling Research Station for use in triplicate, in a *Verticillium* resistance trial in 1953.

NUTRITION OF THE HOP

Laboratory Investigations

A diffraction grating spectrophotometer is now in use in the department and methods have been developed for the determination of phosphorus, iron and manganese, using this instrument.

Long Term Manurial Trial

This experiment is designed to study the effects of nitrogen, phosphorus, potassium and magnesium fertilizer applications on the yield, nutrition and resin production of hop plants. Analyses of leaf and cone samples collected in 1951 were completed in 1952. In addition to the direct effect of applied fertilizers on nutrient uptake, leaf analysis showed some interesting effects due to interactions between nitrogen and phosphorus, phosphorus and calcium and potassium and magnesium. None of the fertilizer treatments had any significant effect on resin production in the hop cones.

Yield data were again obtained in 1952. Treatments had a marked influence on the dry matter content of the cones this year, with the result that the yield of dry hops showed very different trends from the yield of green hops. In terms of dry hops, high level phosphorus, potassium and magnesium all increased yields by approximately 1 cwt./acre, while high nitrogen decreased the yield by the same amount. The phosphate effect is considerably lower than that found in 1951 and the magnesium effect appreciably greater.

Pot Culture Experiments

The experiment on the effect of soil acidity, which is being conducted on three types of soil in barrels, was continued for its second year. Interesting results are being obtained on the relationship between soil acidity and the uptake of mineral nutrients by the hop, and upon the effect of soil acidity on the growth of the plant.

A water culture experiment was carried out, growing a series of hop plants in a complete nutrient solution and removing whole plants from the culture solution for analysis at intervals throughout the growing season, in order to get a measure of the time and rate of nutrient uptake.

The boron-calcium sand culture experiment has been continued. Boron deficiency symptoms have been produced and there appears to be an intimate relationship between boron and calcium nutrition.

The series of sand culture experiments designed to develop symptoms of other mineral deficiencies, has been maintained for demonstration purposes.

Mineral Deficiency Plots

The plots at Goudhurst, Kent, and at Piltdown, Sussex, were maintained. The former showed excellent development of symptoms of potassium and magnesium deficiencies both singly and in combination. At Piltdown, potassium-induced magnesium deficiency showed up clearly in 1952 and the influence of the level of nitrogen on symptom expression was also evident.

Grassing-down Hops

Satisfactory growth of hops was obtained in a sward of S50 Timothy and S100 Clover, using a system of management involving mowing and grazing with sheep. This trial is on a clay soil. Similar plots under S143 Cocksfoot and S23 Rye Grass respectively made unsatisfactory growth under this system of management.

A further trial, of random block design, was laid down on a soil derived from the Tunbridge Wells Sand, using S23 Rye Grass, S50 Timothy and S59 Red Fescue in combination with Wild White and S100 Clover.

Observations were carried out on a third trial on a commercial farm, where good growth of hops was obtained in swards of S50 Timothy/wild white clover and S23 Rye Grass/wild white clover using a gang-mowing technique. In this trial the influence of

manuring on growth clearly demonstrated the need for additional fertilizers for hops under grass.

A more detailed account of this work appears on page 24 of this Report.

THE CONSTITUENTS OF THE HOP CONE

Variation of Resin Content with Position on the Bine

The results of this year's work indicate general confirmation of previous investigations that, although there is a variation in the percentage of resins with position on the bine, there is no obvious correlation between position of cone and amount of resin. The same three positions were chosen this year on the same hills as in 1951 and it was found that the maximum resin content sometimes occurs at the top, sometimes in the middle and sometimes in the lowest hop of the bine. These results do not support the hypothesis that the cones on the upper parts of the bine contain a higher percentage of resins, indeed, frequently the reverse is true.

Formation of Resin During Ripening

We have continued the investigation on the formation of resins during ripening for a third season; the results of the three years 1950-52 can be summarized as follows:

(1) Humulone is present from the earliest time that the cones can be sampled; this was during the first week of August when between 2,500-3,000 dried cones were required for 100 gm. of dried hop, the figure varying with the year and with the variety.

(2) The increase of humulone and total soft resins, calculated on a gram per cone basis, proceeds steadily over a period of 3-5 weeks according to the variety and year.

(3) The maximum of both humulone and the total soft resins is reached in approximately the same time, although the maximum of the latter has been noticed in some cases to be delayed for a few days.

(4) The humulone content remains practically constant for periods varying between 10 and 25 days, covering a period during which the cones were considered to be under-ripe, ripe, and over-ripe. This steady period varied with variety and year, 1950 and 1952 being the longer and 1951 the shorter.

(5) The total soft resin content during this period did not remain as steady as the humulone content, though this may possibly be due to experimental error.

Deterioration of Hops During Storage

The four varieties chosen for this experiment were Brewer's Gold, Northern Brewer, Early Bird and Eastwell Golding. In addition to the standard Ford and Tait gravimetric analysis, the samples were analysed for their peroxidase content by the method described later in this Report (see p. 59). The results and conclusions may be summarized as follows:

1. *Storage in Gases*

Nitrogen: deterioration in this gas is arrested, provided the replacement of air is complete. This confirms our previous results. The peroxidase content appears to suffer little change compared with air storage, it is fairly constant up to June (from the previous October) but falls between June and August.

Oxygen: this gas increases the rate of deterioration so that Northern Brewer and Brewer's Gold are devoid of humulone by February. In the case of Northern Brewer, but not of Brewer's Gold, the peroxidase content shows a greater rate of loss during this six months period of storage than the air stored samples. At the end of the storage period the peroxidase content is less than in the air stored samples.

Hydrogen Sulphide: the rate of deterioration is nearly, but not entirely arrested by storage in this gas. This slight deterioration is probably due to imperfect replacement of air by the gas. The peroxidase is considerably but not entirely inactivated. Samples treated with hydrogen sulphide for one week to inactivate the peroxidase and subsequently stored in air show no decrease in the rate of deterioration; it would, therefore, appear that peroxidase is not responsible for deterioration of humulone.

These results confirm, in general, those obtained in previous years.

2. *Steamed Green Hops*

Samples of green hops were subjected to the action of steam before drying; this sterilizes the hops and hastens drying, but it was found that hops treated in this way deteriorated more rapidly than the control untreated samples. Steaming completely inactivated the peroxidase. This confirms our previous results.

3. *Selective Absorption of Moisture and Hop Oil*

Samples were stored in the presence of phosphorus pentoxide (which absorbed moisture and hop oil); silica gel; zinc chloride; and calcium chloride; these absorbents were replaced as soon as saturated —during the early part of storage about once every two weeks and later on once every three months. There was no significant difference between any of the samples in any of the four varieties, although they deteriorated at a slower rate than the air stored samples. This is undoubtedly due to the lower relative humidity of the storage conditions.

The different treatments appeared to have little effect on the peroxidase content of the hops.

4. *Storage at Different Relative Humidities*

In previous years this experiment has suffered from two defects, (*a*) the phosphorus pentoxide used for the lowest relative humidity absorbed hop oil as well as moisture from the atmosphere, (*b*) the highest relative humidity promoted growth of moulds on the sample.

This year (*a*) was overcome by using silica gel, and (*b*) by treating the samples with formaldehyde for one week, then storing in the presence of various concentrations of sulphuric acid calculated to give moisture contents of approximately 9 per cent., 15 per cent., and 24 per cent. No fungoid growth was observed.

The previous years' results were, however, confirmed; these indicated that the drier the hop the slower was the rate of deterioration.

The formaldehyde, *or* the changes of moisture content of hop which attended the preparation of the samples, caused a considerable decrease of peroxidase activity, which remained at a low level throughout the storage period.

Analyses of Hops

During the period under review a total of 614 samples of hops were analysed, as follows:

108 Samples of selected Goldings.

38 Samples of Prof. Salmon's New Varieties.

100 Samples for the Institute of Brewing's Exhibition of New Varieties. (50 samples in duplicate.)

88 Samples for the Survey of Hop Picking Machines.

36 Samples for the investigation of the formation of resins during the ripening period.

60 Samples for the investigations of the variation of resin content with position on the bine.

184 Samples of hops kept under different storage conditions.

HOP DRYING

Use of Sulphur During Drying

The present shortage of sulphur raises the question as to whether its use in hop drying is essential. Although undoubtedly the practice of sulphuring hops during drying improves their appearance, little is known with certainty about its effect on their brewing value. Three series of experiments were made, on the varieties Early Bird, Fuggle and Petham Golding, to study the problem. These were dried with various amounts of sulphur and with SO_2 from the liquefied gas, with non-sulphured control samples. The treated hops will be submitted to commercial valuation and will be analysed periodically to find whether there is any difference in keeping properties. The bulk samples will be sent to the Brewing Industry Research Foundation for brewing trials.

Results from a similar trial, made in 1951, indicate that the keeping properties of hops are not affected by the use of sulphur during drying.

Temperature of Drying

The results of previous work on hop drying have shown that, while the market value of hops decreases as the temperature at which they are dried increases, the best flavoured beer is produced by the use of hops dried at a moderate temperature of about 150° F. (*Jour. Inst. Brew.*, **43**, 1, 9. 1937). Three series of experiments were made in which each of the three varieties of hop mentioned above were dried at six different maximum temperatures, ranging between 130° F. and 180° F., to provide material for further brewing trials to be made in the experimental brewery of the Brewing Industry Research Foundation on this important question.

Drying Broken Hops

A certain amount of breakage inevitably occurs when hops are picked by machine and the special problem of drying these broken hops arises. A preliminary investigation was made this year on the effect of breakage of the cones on the rate of drying.

Resistance to Air Flow

A small experiment was made to study the relationship between air speed, depth of loading and the air pressure below the load of hops, to provide information needed in connection with kiln design.

Drying Special Hops

Several small lots of new variety hops were dried under controlled conditions for brewing experiments.

SURVEY OF HOP-PICKING MACHINES

The survey of picking machines was continued by Mr. Gibb, of the College Engineering Department, and Mr. Chater, of the N.A.A.S. West Midland Province, with the assistance of Mr. Merridew (Wye College), Miss Jary (N.A.A.S.), Mr. Pearce (N.A.A.S.) and a team of students of Wye College.

Eight of the machines surveyed in 1951 were again surveyed in 1952 together with four new models in commercial use; a preliminary survey was made of a prototype mobile machine.

Alterations in the details of the survey from those of 1951 included the subdivision of "broken hops" into "partly broken" and "completely broken" and the analysis of commercially hand picked hops for comparison with machine picked. 140 samples of hops were taken and dried separately for chemical analysis in connection with the survey. An account of the 1952 survey will be found on p. 43 of this Report.

EXTRA-MURAL ACTIVITIES

A paper was read by Dr. Burgess to a joint meeting of the Food Group of the Society of Chemical Industry and the London Section of the Institute of Brewing on "The chemical aspects of hop culture"; Mr. A. R. Tatchell also read a paper at the same meeting on "The chemistry of hops as prepared for market". Talks were also given by Dr. Burgess to Hampshire hop-growers on "Advances in hop growing" and to the East Sussex N.F.U. on "Storage of hops on the farm".

Meetings of the Hops Marketing Board New Varieties Committee, the Institute of Brewing Hops Sub-Committee, and the Committee of the Association of Growers of New Varieties of Hops were attended by Dr. Burgess. A meeting of the Scientific Committee of the European Committee on Hop Culture, in Brussels, was attended by Dr. Burgess and Dr. Dark.

Advice has been given relating to the hop experiments and construction of the new oast-house at Rosemaund Experimental Husbandry Farm.

Close liaison has been maintained with the Hops Marketing Board, the Institute of Brewing, and the N.A.A.S., and the Department has co-operated in the work on hops carried out at East Malling Research Station and the Brewing Industry Research Foundation.

ADVISORY WORK

Advisory work, which has been continued in co-operation with the N.A.A.S., has included problems of manuring, cultivation, selection of sites for new gardens, design and modification of oast-houses and management of drying.

Advice has also been given to commercial firms and others seeking information on various aspects of hop growing.

GENERAL

Visits were received from members of the Spanish Hop Growing Institute and from a party of Belgian hop advisers and officials from West Flanders. Other visitors to the Department came from New Zealand, Australia, U.S.A., and Sweden, as well as growers from this country.

Four lectures on Hop Growing were given to the 2nd Year Agriculture Students of Wye College.

PUBLICATIONS

1. E. S. Salmon. "Norton Court Golding." A new hop. Wye College Leaflet, April, 1952.
2. Department of Hop Research. Report for 1951. July, 1952.
3. F. C. Thompson and A. H. Burgess. "Influence of Mineral Nutrition on the Resin Content of the Hop Cone." *Nature*, **170**, 890, 1952.
4. J. A. C. Gibb and G. P. Chater. "The Mechanization of Hop Picking." *Agriculture*, **59**, 25, 1952.

A. H. Burgess,
Head of Department of Hop Research.

THE SOIL REQUIREMENTS OF THE HOP PLANT

1. A GENERAL ACCOUNT OF THE SOILS ON WHICH HOPS ARE GROWN

F. C. Thompson

The need for a deep soil of good drainage and medium texture for the satisfactory growth of hops has been stressed by a number of writers in the past, and it would be expected that a deep-rooted perennial plant would only make maximum growth on such a soil. Nevertheless the growth characteristics of different varieties of hops must be taken into account and while it may well be that the high quality Golding hops will only do well on the best soils, there is no doubt that the Fuggle variety is not so exacting in its requirements.

It is of interest to note that when the hop acreage reached its maximum in this country in the third quarter of the nineteenth century, hops were being cultivated in 40 counties on a wide range of soils. Among the hops in cultivation at the time were varieties such as Jones's which were described by writers of the period as capable of being grown "almost anywhere"—Parker, 1934. These varieties, however, were of poor quality and have now gone out of cultivation. At the present time the Fuggle variety which was introduced in 1875, forms some 75 per cent. of the acreage grown, Golding and "Golding Variety" hops taking up 20 per cent. of the acreage and the remainder consisting of miscellaneous varieties, largely those bred at Wye and introduced in recent years.

In the course of experimental and field work carried out in the past four years the writer has had the opportunity of examining soils in the major hop growing districts of England. If we consider the soils developed from the various geological formations found in the hop growing districts in this country, they can be located in the following groups, which approximate to the classification adopted by the Hops Marketing Board.

East Kent District

The typical soils on which hops are grown in this district are the brickearth soils of the Faversham area, these soils originating as wind-borne deposits. In addition hops are found on loamy soils derived from the Thanet Sand and to some extent on relatively thin soils overlying chalk—e.g. in the Chatham area.

The deep, mellow brickearths are ideal soils for hop growing, but surprisingly good growth can be made on the thinner soils, though these are, of course, more subject to the influence of seasonal conditions, particularly drought.

Mid-Kent District

This can be considered as the district around Maidstone and the hop soils are primarily associated with the Lower Greensand formation. Hops are to be found on sedentary Hythe Beds soils in the area both to the South-West and South-East of Maidstone. In addition hops occur on colluvial soils, formed by downwash from the Hythe Beds, on the slopes of the Medway valley near to Maidstone and on deep alluvial soils in the valley itself.

Weald District (Low Weald)

The main area of hops in the Low Weald does not actually occur on the Weald Clay but is located on an area of alluvium formed by the deposition of material brought down from the High Weald by the River Medway and its tributaries the River Teise and the River Beult. This area extends North-East from Tonbridge, through Hadlow and East Peckham, and joins on to the Mid-Kent District; it also extends more directly East through Paddock Wood to Marden, again joining up with the Mid-Kent District.

Some hops in the Low Weald area are grown on the true Weald Clay, the soils being sedentary soils derived direct from the parent material. In some cases the soils may be no more than 6 to 9 in. deep over the clay sub-soil, but useful crops of hops can be grown when the land is heavily dunged.

Weald District (High Weald)

This is a very productive hop growing district centred on Goudhurst, the best soils being the light to medium loams derived from the Tunbridge Wells Sand—either deep sedentary soils, or alluvial or colluvial (downwash) soils, some of the alluvium being of brickearth type.

The Teise valley running north from Goudhurst is a highly productive area where the soil is a mixture of colluvial and alluvial material derived from the Tunbridge Wells Sand and the Wadhurst Clay, the top soil overlying freely draining Ashdown Sand.

Elsewhere in this district hops also occur on sedentary soils derived from the Wadhurst Clay, which is similar in character to the Weald Clay; also on heavy alluvial soils overlying the Wadhurst Clay.

Sussex District

In Sussex the hop growing district is confined to the Hastings Beds formation, hops being grown on either the lighter soils derived from the Ashdown Sand and Tunbridge Wells Sand or the heavier soils formed from the Wadhurst Clay. In effect this district is really an extension to the South-West of the Kentish High Weald district, but larger areas of Wadhurst Clay occur in Sussex with the result that more hops are found on soils resembling those derived from the Weald Clay. There are also large areas of heavy alluvial drift in the Rother Valley where there is a considerable acreage of hops.

Hampshire-Surrey District

Here hops are grown on the alluvial soil found in the valley of the River Wey in an area from Farnham in Surrey, South-West to Alton in Hampshire. To the North-West of the valley the hops extend on to the Upper Greensand formation. There is also an area of hops on the Weald Clay around Petersfield in Hampshire.

Hereford

Practically the whole of the hop acreage in Hereford is found on the Old Red Sandstone formation which gives rise to heavy "Red Marl" soils and also to soils of lighter texture; the main acreage of hops occurs on the heavier soils. The valleys of the River Frome and the River Lugg form the centre of the hop growing district. Hops can occasionally be found on other formations as for example on Wenlock Shale at Woolhope.

Worcester

The main hop growing area in Worcester is located on deep loams derived from the Old Red Sandstone or on deep alluvial soils, both being found in the Teme Valley extending from over the Shropshire border through Tenbury down towards Worcester. This is the area where the well-known Mathon hop grows particularly well. Some hops are grown on the heavier soils derived from the Keuper Marl in the Malvern district and on light drift soils near Pershore.

Soil Requirements in Relation to Variety

Small areas of hops can be found in other counties on different geological formations, so that it will be seen that when the general picture is considered the main feature brought out is the wide variety of soils on which hops are grown. In fact hops are found

on soils of shallow to moderate depth over clay or sandrock; on deep alluvial and downwash soils; on well-drained and poorly drained soils and on soils derived from very different parent materials. When the variety of hop grown is taken into consideration, however, it is found that the Fuggle variety is the one which is grown on the wide range of soils, and the high quality Golding and Mathon hops which form some 20 per cent. of the total acreage are largely confined to the deep brickearths and loams derived from the Thanet Sands in East Kent, and the deep alluvial soils of the Teme Valley in Worcestershire. Outside these districts occasional small patches of Goldings may be found on localized areas of brickearth or alluvial soils and the so-called "Golding Varieties" (i.e. Cobbs and Tutshams) can be found more widely distributed, in particular being grown fairly widely on the Lower Greensand in the Mid-Kent district; some gardens of the Tutsham variety are also to be found in the Kentish High Weald district.

A marked feature of the Fuggle hop is its tolerance of heavy soil and wet conditions. It thrives best on an abundant water supply and grows well on the heavier clay soils. Where there is a high water-table it does not appear to need a great depth of soil and in fact it may be said that its ability to withstand poorer soil conditions may be related to its ability to make useful growth on a relatively shallow root system. This is not to say that the Fuggle variety will not develop a deep, vertical root system on soil of good depth, texture and drainage, and that under such conditions the growth made will not be better than that on poorer soils, particularly in a dry season. It is, however, of interest to note that on a deep brickearth at Wye, Fuggles have not done as well as in the best Fuggle growing areas in West Kent, but this may be a climatic rather than a soil factor.

The new (Wye) varieties of hops, the acreage of which is steadily increasing, were initially grown on the better soils and there is now a definite need for testing out their performance, under controlled conditions, on a wide range of soils and particularly on those which are regarded as "typical" Fuggle soils. Such evidence as there is suggests that certain of the varieties (e.g. Early Promise and the Wilt resistant variety OR55) can do well on the heavier and wetter soils, and it may well be that others of the new varieties will do equally well on such soils.

THE SOIL REQUIREMENTS OF THE HOP PLANT

2. THE MAINTENANCE OF SOIL STRUCTURE WITH PARTICULAR REFERENCE TO THE GROWTH OF HOPS IN GRASS/CLOVER LEYS

F. C. Thompson and Miss C. L. Jary (*Hops Advisory Officer, S.E. Province N.A.A.S.*)

Introduction

The breakdown of soil structure in land under hops in S.E. England has become a problem of increasing importance. It can arise from two main causes:

(1) Continual cultivations which pulverize the soil and increase the rate of oxidation, and so the loss, of organic matter.

(2) The continual passage of tractors and implements along the same tracks in the alleys, frequently under wet conditions.

The bad effects of soil compression by heavy machinery, particularly when working under wet conditions, are generally recognized, but the effect of cultivation on the rate of loss of organic matter is less widely appreciated. Some experimental data from the U.S.A. have shown that annual dressings of 10 tons per acre of farmyard manure are insufficient to maintain the organic matter in a soil under continual cultivation and further evidence from Canadian experiments suggests that annual dressings of the order of 20 tons per acre are needed.

Both the lighter sandy soils and the heavier clay soils on which many of the hops in S.E. England are grown contain a high proportion of particles of very fine sand, which unless bound together to form larger aggregates tend to pack tightly and produce soil which is very difficult to work. It is largely the organic matter which causes the aggregation of these smaller particles into "crumbs" thereby opening up the soil and providing the best physical conditions for plant roots and other living organisms.

Traditional Use of Bulky Organic Manures

It has been traditional to use very large quantities of bulky organic manures on hops to keep the soil in a reasonably workable

condition. Farmyard manure and shoddy are the two most widely used materials in this category, but feathers and rabbit flick are also common. They are applied at relatively heavy rates; farmyard manure from about 10 tons per acre upwards and the others at roughly 1 ton per acre.

There are a number of other fertilizers of natural origin which are termed "organic" fertilizers, as for example meat and bone meal, castor meal, etc., which are used on hops, but these are not normally given in dressings of more than 5 to 10 cwt. per acre and should be considered as a source of plant nutrients rather than as a means of supplying humus to the soil in appreciable amounts.

Deterioration of Structure of Hop Soils

These heavy dressings of bulky organic manures have helped to maintain soil structure in the past, but now with increasing costs both of the manures themselves and also of labour for carting and spreading, their use is declining and the breakdown of soil structure is becoming noticeably widespread.

Organic matter improves the structure of soil by promoting granulation, and the colloidal material which arises from the decomposition of organic matter has a very high water-holding capacity, thus acting as a reservoir. Soil water is also held in the small pores or air spaces between the soil particles; in the coarser sandy soils these pore spaces are frequently too large for maximum water retention, and humus by decreasing the pore size increases the water-holding capacity. In a heavy clay soil, and also in a so-called light soil containing a high proportion of very fine sand particles, the reverse takes place in that the pore spaces tend to be too small, and here organic matter prevents the particles from packing too tightly. The degree of aeration is influenced by the pore size both directly, in so far as this governs the amount of air present in the soil, and indirectly in that where the soil particles are packed tightly together they tend to retain an excess of water and so exclude air. Both processes result in the death of roots owing to lack of oxygen.

It will thus be seen that deterioration of soil structure through loss of organic matter will restrict root range and so prevent full growth of the hop plant even in a "normal" season, while under drought conditions the effect will be even more marked. In addition, nutrient uptake is restricted as a result of the poor root system developed, so that mineral deficiency troubles can arise even where

the soil is found, on analysis, to contain a high level of available nutrients.

Impeded drainage shows up particularly where a pan has developed some inches below ground level, owing to the continual passage of heavy implements and machinery along one track. The impervious layer so produced prevents the free drainage of water and so leads to water-logging of the surface soil under wet conditions. The presence of this layer, which usually cannot be penetrated by roots, is a further factor restricting root range. Soils of poor structure tend to develop pans more readily than those where structure is good.

The effects of loss of structure can thus show up in the following ways:

(1) Loss of water-holding capacity.

(2) Poor aeration.

(3) Impeded drainage.

Soil erosion is an additional problem. On sloping gardens, rain-washing can rapidly cause erosion of the upper part of the slope and again this is more marked where structure is poor and the water-absorbing capacity of the soil reduced. The effect of this erosion process is to leave a shallow soil at the top of the slope while filling up the ditches at the bottom. These shallow areas in turn, give rise to poor growth and inability to withstand drought, and represent a permanent loss of good soil. Erosion is accentuated by the practice of "striking-up" and of ploughing up and down the slope.

Maintenance of Soil Humus

It has become urgent, therefore, to consider alternative ways of building-up and maintaining the humus content of hop soils and thus of restoring structure and maintaining plant growth. It will be seen from the foregoing discussion that under a system of clean cultivation the quantity of organic manures which must continually be added to maintain humus is now uneconomic. Possible alternatives are:

Green Manuring

This could be used in place of, or in conjunction with dung, but no very large addition to the soil organic matter can be expected from ploughing in green crops. The effect of such crops in holding

the surface soil and preventing erosion through rain-washing is valuable and there are other minor effects which may be beneficial, but with hops the difficulty is to find a crop which will make sufficient growth in the short season available between (or just before) hop picking and the spring ploughing of the land in March. Mustard and rape are used in some cases and Italian rye grass is a possibility, but the ploughing in of a heavy crop of weeds such as chickweed is probably little less effective. Feeding off a green crop or a weed cover with sheep, is sometimes used and should be of additional benefit to the land even though the bulk of material to be ploughed in is reduced.

Straw Mulching

This method has been tried with fruit, particularly soft fruit, with considerable success, but large quantities of straw are required and the price may be such as to make the process uneconomic. Practical difficulties are also likely to arise in adapting the process to hop growing and there is always the risk of damage by fire.

One small trial is known to have been made with hops using 5 tons of straw per acre but the results obtained so far appear to be inconclusive. Weed growth has not been fully controlled with the quantity of straw applied. The practicability of this method has, therefore, yet to be proved.

Grass/Clover Leys

The establishment of a grass/clover or straight clover ley is nowadays regarded as the best method of restoring and maintaining the structure of soils. The effects of a ley on soil structure have been studied and it is known that the grass roots themselves have an important effect both in their physical penetration of the soil and the secretion of gummy substances which help to bind individual small particles into larger crumbs. The inclusion of clover in the sward is a further advantage in that it leads to a definite increase in available nitrogen. If the sward is kept close by mowing, the short mowings rot down quickly and so add humus and plant nutrients to the soil. Similarly if the sward is kept short by sheep grazing, humus and nutrients are returned in the form of dung and urine. There is as yet no experimental evidence to show which procedure has the more beneficial effect on soil structure, though there is an indication that earthworm activity receives a greater stimulation from dung and urine.

The Growth of Hops Under Grass

The growth of top fruit under grass and grass/clover swards is an established practice and the idea of growing hops under grass seemed worthy of trial. When considering the matter a number of difficulties which might arise at once came to mind. On the nutritional side the sward might be expected to compete with the hops, primarily for water and nitrogen. As regards management the problem of keeping the grass short was the obvious one. This could be done by grazing with sheep for much of the year, but during the period April, May and June sheep could not be allowed in the hop garden. As this is the time when the flush of growth is strongest an effective means of mowing the grass would be essential during this period.

Experimental Work

With these difficulties in mind a trial was laid down in East Sussex in 1950 on a heavy, alluvial soil overlying Wadhurst Clay. The seeds mixtures chosen were:

S.143 Cocksfoot and New Zealand Mother White Clover.

S.23 Perennial Ryegrass and Wild White Clover.

S.50 Timothy and S.100 White Clover.

The seeds rates were, Cocksfoot at 16 lb. per acre, Ryegrass at 14 lb. per acre, Timothy at 10 lb. per acre, and the Clovers at 3 lb. per acre.

The plots were sown in the early summer (May) of 1950, so that 1951 was the first season of full establishment of the swards and gave the first opportunity for making detailed records and observations on their effect on the growth of the hops. Under "Ryegrass and Clover" and "Cocksfoot and Clover", the hops were appreciably checked and gave a significantly lower yield when compared with the clean cultivated hops. The plots were cut during the summer with an Allen Auto-Scythe, but unfortunately the grass at one stage (at the spring flush of growth) was allowed to get too long so that virtually a hay crop had to be taken off. In addition, nitrogenous manuring was at too low a level, so that the hops suffered from nitrogen starvation. It was noteworthy, however, that the "Timothy and Clover" plot which suffered from the same set-backs as the other grass plots, nevertheless gave growth and yield of hops equal to that on the clean cultivated plots. The Timothy, being a weaker grass, competed much less with the hops than did the Cocksfoot and

Ryegrass and also produced a sward containing a higher proportion of White Clover.

During the winter of 1951-52 the plots were grazed by sheep until about the end of March, 1952. For the next three months of 1952 the Allen Auto-Scythe was again used to keep the grass short, and in this year was fitted with an attachment to the cutter bar which enabled it to cut closer to the ground. 1952 was a drought year and hop growth in general was poor, except on the deep loamy soils. The Clovers did not come through the winter of 1951-52 well and the swards were no longer clover dominant. Heavier nitrogenous manuring was carried out in this year, the first application being made towards the end of March; nevertheless, under Cocksfoot and Ryegrass, growth was definitely poor. The Timothy plot, however, maintained growth as good as, if not better than, the clean cultivated plot throughout the season, except for a check when the sheep were brought on to the plot at the beginning of July and stripped the lower leaves. The cultivated hops were stripped rather later, so for a time they looked better than those under Timothy, but they in turn were checked after stripping. At the end of the season the crop on the Timothy plot was assessed as being at least as good as that on the clean cultivated plot; that on the Cocksfoot plot was definitely poor, with the Ryegrass rather better but still poor.

Observations at another Centre

Observations have also been made on some grass plots laid down by a hop grower on his own initiative. The mixtures sown were S.23 Ryegrass and S.50 Timothy, both with Wild White Clover. The grass is kept very short by regular gang mowing and heavy manuring is carried out. The soil at this centre differs from that at the centre described above, being lighter and better drained.

A variation in manuring tried out in 1952 produced a striking result. The total manurial programme was (per acre) 403 lb. N, 509 lb. P_2O_5, 553 lb. K_2O. The application included 20 cwt. per acre of a potato manure put on in early February, and which supplied (per acre) 134 lb. N, 186 lb. P_2O_5, and 268 lb. K_2O. This dressing was omitted from a strip of a few rows, and these rows showed markedly poorer growth and leaf yellowing indicative of nitrogen deficiency. The level of nutrients applied to this strip amounted to (per acre) 269 lb. N, 323 lb. P_2O_5, 285 lb. K_2O. Soil samples from this garden showed that the levels of phosphate and potash were very satisfactory and the remarkable difference in appearance,

therefore, was apparently due to the omission of the extra nitrogen (134 lb. N per acre) in February, from the strip showing poor growth.

Since 1952 was a dry year it would, therefore, appear that at this centre hops can withstand competition for moisture provided they get enough nitrogen applied early in the season.

Tentative Conclusions and Recommendations

The conclusion tentatively reached as a result of these observations is that grassing down can succeed provided that:

(1) the grass is kept short, and grazing (if practised) properly managed;

(2) the right herbage mixture is used;

(3) proper manuring is practised.

All these points must be met if grassing down is to be successful. Failure in any one of them can lead to disaster.

The tentative recommendations put forward under these headings are as follows:

(1) Gang mowing is the only really practicable method so far tried of cutting the grass satisfactorily on large areas.

(2) S.50 Timothy with S.100 White Clover or Wild White Clover is the most suitable mixture of those yet tried. Wild White probably stands up to winter grazing rather better, but S.100 is thought to stand up better to heavy nitrogenous manuring.

(3) Manuring should be modified to prevent the soil from becoming acid, thus discouraging the clover. It is most important to give sufficient nitrogen, and it is evidently desirable to give it earlier than the normal times.

The manurial programme now suggested is:

10 cwt./acre Basic Slag in autumn.

3 cwt./acre Muriate of Potash (60% K_2O)
or 4 cwt./acre Muriate of Potash (40% K_2O) } Preferably applied in two dressings in February and March.

5 cwt./acre Nitro-chalk in early February.

5 cwt./acre Nitro-chalk in mid-March.

5 cwt./acre Nitro-chalk end of April.

3 cwt./acre Nitro-chalk end of May.

The quantity of nitrogen suggested is based on the performance of the trials at present under observation. These have generally not

retained the clovers too well in the second year. With a greater persistence of clovers the amount of nitrogen could be reduced. In addition, experimental results have shown that the effect of a ley is to increase the availability of phosphate and potash in the soil, so that after a period in a ley it should be possible to reduce the quantities of phosphatic and potassic fertilizers applied.

Other Points of Management

Training. During April and May when training is in progress it is usual to leave surplus bine lying about on the ground in case it is wanted later. It is not practicable to do this with gang mowing, since there will obviously be far greater damage to such bines than would be caused by cultivations, and mowing must be done more frequently than cultivations at this time. It is probably desirable, therefore, to train up more bine than will eventually be required and pull out the surplus later.

Grazing. The use of sheep for grazing except for the three months mentioned is quite practicable and appears definitely desirable. Grazing cannot be quite continuous for the rest of the year; resting periods must be allowed during the winter and spring, and the fertilizers can be given at these times. Sheep must also be kept out for suitable periods after spraying with poisonous substances.

Dressing. Traditional methods of dressing cannot, of course, be practised. As there is no cultivation at all even close to the hills, they cannot be opened up. Dressing, therefore, consists merely of cutting off the bases of the bines at soil level. There is no evidence so far to indicate that the hills suffer as a result and runners seem to be effectively controlled by the close mowing and grazing.

Further Experiments

It must be emphasized that the amount of work hitherto done on the grassing down of hops is very small, but it is hoped to obtain more experience and precise information from a new series of plots sown down in 1952. These are designed to try out certain other features:

(1) An alternative weak growing grass—S.59 Red Fescue—which is known to be particularly effective in depth of root penetration.

(2) Combinations of Wild White and S.100 Clovers with all grasses.

(3) Each of these clovers alone.

The experiment is designed with three replications so that results obtained will be capable of statistical analysis.

Economics of Grassing Down

The evidence to date indicates that hops can be grown under grass with proper management. It remains to examine the economics of the system and compare them with those of the traditional methods of arable cultivation. Estimates of costs show that there is a definite saving by the omission of organic fertilizers under grass. Gang mowing is also shown to be cheaper than cultivations where these are taken to include winter ploughing and striking-up in addition to summer work. Such estimates are based on the assumption that a reasonably large area of, say, 10 to 12 acres is involved. While this is not an economic area for full utilization of the gang mower, it is assumed that the grower would have fruit under grass as well and so make the most efficient use of his mower. From the long term aspect the development of a type of mower specially adapted for hop work may be the best answer to the problem. The greater ease and convenience of handling implements and machinery, such as spraying tackle, is a further factor in favour of grass.

Conclusion

The problem of deterioration of structure of many soils on which hops are grown is now recognized and is of increasing importance. The traditional methods of supplying organic matter in the form of farmyard and other organic manures, in the amounts required to maintain soil structure, is becoming uneconomic. Experimental evidence has shown that putting land down to a ley is one of the best means of building up soil structure, and preliminary trials indicate that under proper management it is possible to grow hops in grass. Where the management is such that the crop produced is equal to that from arable cultivation under comparable conditions then there is a strong indication that growing under grass should be cheaper, particularly where the traditional methods of manuring with expensive fertilizers and frequent cultivations are still the practice. Finally, over a period of years, the effects of the ley should be such as to result in increased yields on soils which have lost structure.

Acknowledgments

Our thanks are due to Mr. H. G. Chippindale, Grasslands Advisory Officer at the Wye Sub-Centre, N.A.A.S., for advice and assistance in carrying out the trials of hops under grass described in this paper, and to those growers who have kindly provided facilities for the trials.

Acknowledgment must also be made to Mr. M. Brewin, of Wye College, for information on hop costings, and to Mr. D. W. P. Greenham of East Malling Research Station for data on green manuring and grassing down experiments with fruit.

THE USE OF POLYPLOIDY IN HOP BREEDING

S. O. S. Dark

The ordinary plant breeding methods will produce large numbers of "new" varieties of hops. The genetical composition of the hop plant is always hybrid. In normal hop growing, this characteristic of hybridity is unimportant, because the varieties can be maintained true and constant by vegetative multiplication. When hop varieties are used for breeding, however, their hybrid nature is immediately evident in the offspring, which differ from each other, and also from their parental forms. New and improved combinations of characters within individual plants can be picked out from these progeny and propagated as new clones; but the original parental type will not be recovered.

The brewing industry on the whole is not enthusiastic about new hop varieties; they ask for varieties which resemble the old established ones in all important characters, but with the addition of desirable improvements. For example a Fuggle hop which was resistant to *Verticillium* Wilt disease would be very popular.

A new breeding technique has, therefore, been worked out in an attempt to breed varieties of hops "to order". The theory of the new breeding method is simple, although its application is rather complicated by various practical difficulties.

The Theory of the Method

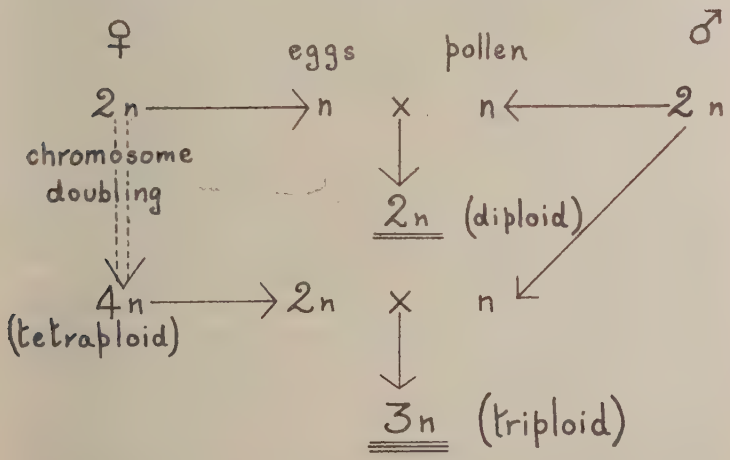
The hop plant which it is desired to improve contains in all its cells two sets of genes which interact with the environment to produce the observable characteristics of the plant. The essential characters of the plant depend upon the balance of these different sorts of genes, which are the same within all the cells making up the plant, and half of these genes were contributed by the mother of the plant and half by the father. However, when the plant develops its egg cells for breeding further generations, only half of the genes can enter any one egg. Thus it is obvious that none of the egg cells produced by a Fuggle plant can obtain all the mixture of genes necessary for producing another Fuggle plant.

Since the genes are carried upon the chromosomes in the cell nucleus, we can overcome this difficulty of losing half the genes

from the egg by treating the plant in such a way that its cells contain four instead of the normal two sets of chromosomes—hence doubling the number of genes—and so its eggs will contain twice the usual number of genes, that is approximately a full set of them instead of the usual half set. This process is called polyploidizing, and the first step in this breeding method is to make an auto-tetraploid form of the original hop, that is one in which every cell contains two identical chromosome sets or 40 chromosomes instead of the normal 20.

These tetraploid hops are then used in controlled crosses with tested ordinary diploid males (having 20 chromosomes). The outcome of this cross will be another type of polyploid—the triploid, i.e. it contains three chromosome sets, two from the tetraploid mother and one from the diploid father or 30 chromosomes in all.

The process can be represented by this diagram:



Triploid plants have general properties and characteristics which in three ways should prove valuable when applied to hop breeding.

Firstly, triploid plants are sterile, i.e. they produce no seeds or only very rare ones. Since this result is attained by failure of the embryo to develop after fertilization, a fully pollinated triploid hop plant should produce fully grown out but seedless cones. The grower would thus obtain a crop of full sized cones which through being

pollinated, had passed rapidly through the burr stage when they are very susceptible to downy mildew and "mould" (powdery mildew). The brewer at the same time would not be paying for the seeds which are useless to him as a brewing material.

Secondly, triploid plants often show increased size or vigour when compared with the diploid or tetraploid forms.

Thirdly, the triploid contains a complete chromosome set derived from the original diploid mother plant, and so a family of triploids should closely resemble the original diploid variety. At the same time, some variation will be introduced into the family by reason of the effects of the genes contained in the third chromosome set of variable composition contributed by the pollen parent.

The Practical Steps in the Application of the Method

Production of tetraploid forms of standard hop varieties.

Polyploid hops have been reported in the literature (Ono, 1948). But since they arose from the treatment of seedlings by colchicine they were of little use because there was no standard with which to compare them. Colchicine treatment of young vegetative buds of the hop varieties Fuggle, Brewer's Gold, Bullion and Wye Field Golding was undertaken in 1950. The method was an adaptation of the colchicine painting system used by Janaki-Amal at Wisley for producing tetraploid plants. Bedded sets were potted during the winter and forced into growth in a heated glasshouse. The buds treated were the very small and relatively undifferentiated axillary buds occurring near the growing tip of the young shoot. When the forced shoots were approximately 1 foot long, and growing strongly with some expanded basal leaves, the first node to be treated was selected as the first node below the growing tip at which the pair of petioles were still lying parallel and tightly pressed to the main stem. These petioles were severed with a fine scalpel just above the axil. The next pair towards the growing point were then severed similarly. This defoliation was continued for about six nodes, or until the tissue was too small to see and handle, and at this point the main stem was decapitated. With the fine point of the scalpel all the axillary buds in each node below the first defoliated node were cut out to the base of the bine.

The mutilated plant was then left for 24 hours to start active growth in the young axillary buds remaining at the top of the shoot. The tip of the shoot from the first colchicine treated node upwards was then painted three times a day for three consecutive days with a 0·5 per cent. solution of colchicine in water, and applied

with a small camel hair brush. Within a few weeks the treated buds grew out into lateral branches which were examined for the presence of tetraploid tissue. Because assistance and time were very limited an arbitrary system had to be used of selecting probable polyploid shoots for propagation. A small circle was punched from each leaf of the shoot as it expanded and the presence of giant stomata (not less than 30μ in length), or contorted or stunted textures of the leaf lamina were taken as criteria of possible tetraploidy. Such selected shoots when long enough (about 4 to 6 inches) were cut from the parent stem and propagated in small pots under bell jars. The shoots were removed for propagation as early as possible to encourage growth of as many as possible of the treated buds.

This colchicine treatment produces tetraploid tissue, but all the cells in the young bud are not affected by the drug. The resulting plants have so far all been chimaeras, that is, they consisted of mixed sectors or layers of induced tetraploid and unaltered diploid cells. The composition of the outer skin or epidermis can be investigated by leaf punching and measuring the stomata. Chromosome counts in the young root tips indicate the composition of the central core of the plant. But the most important test is to obtain seeds from the propagated plant and find out whether the resulting seedlings are diploid or triploid.

A chimaerical plant which is producing a high percentage of triploid offspring can be satisfactorily used for breeding, but owing to the greater rate of growth of diploid tissue, it is possible that over a period of years the percentage of tetraploid tissue would diminish and eventually disappear through being overgrown. The young plants were therefore layered and at the end of their first season's growth were made into single node cuttings to correspond to the nodes whose leaves had exhibited giant stomata. In this way one increases the chances of isolating a pure or nearly pure tetraploid sector as an individual plant, and in subsequent years one might obtain pure tetraploid shoots from buds which had arisen in the tetraploid sectors.

This testing and sorting out of cuttings with tetraploid sectors is a slow business, because chromosome counts cannot be done quickly even when using the latest rapid squash techniques. A more efficient system which we have not yet been able to try is the x-ray technique described by Lewis (1951). Here the chimaeras are resolved at a very early stage by first treating the buds with colchicine, leaving them for a few days to allow the affected cells to multiply, and then subjecting the mixed tissue to a massive dose

of x-rays which is sufficient to kill the diploid cells without harming the more resistant tetraploid ones.

Table 1
Production of Polyploids by Colchicine Treatment.

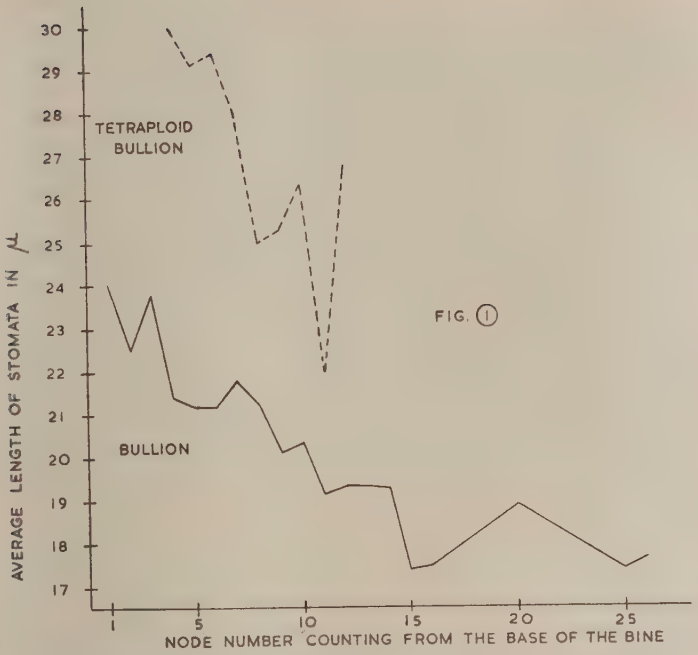
Approximate number of buds treated with colchicine in 1950	200
Number of buds which grew into lateral branches	92
Number of laterals which showed giant stomata	55
Number of plants propagated as being the most promising	12
Number of these selected plants which have produced triploid seedlings	3

The Techniques Used in Determining Polyploidy

(*a*) *Stomata Length*

Because of the comparative rapidity with which the measurements can be made, this method is used for the first sieving of large numbers of plants or seedlings (Ono, 1948). The stomata on the first few leaves of a seedling or on the earliest leaves produced by a cutting are shortest in a diploid, longer in a triploid and still longer in a tetraploid. As the plant grows, however, the average stomatal length diminishes as one samples from later nodes on the bine. This falling off occurs in both diploid and polyploid plants, and the curves overlap so that after about ten nodes the "giant" stomata have become less than 30μ in length (Fig. 1). Hence the rapid division into giant and non-giant bearing plants must be made on comparisons of the early leaves only. This stomatal size criterion of the presence of polyploidy in chimaeras may also be misleading in making these preliminary selections if there should be many cases of periclinal chimaeras produced with diploid epidermis but polyploid interior tissue. In practice this is probably not a serious objection, as it is probable that if any part of the young differentiating bud is going to be affected by the colchicine, the outer skin will be affected before the inner tissues.

The determination is made by removing a small circle of 2 mm. diameter from the expanded leaf by means of a pliers type leather punch. The under surface of the sample is then examined under the microscope with a one-sixth objective and 10 × eyepiece containing a micrometer scale. The presence of stomata of a greater length than 30μ is quickly seen. The determination of the average stomatal length takes a much longer time, because two traverses at right angles have to be made across the area and the length of 30 stomata measured.



Graphs showing the average stomatal length for leaves at each node in a Bullion plant and a colchicine treated Bullion with tetraploid epidermis.

(b) Chromosome Counts

Chromosome counts are the only definite evidence of polyploidy. Vigorously growing root tips from potted cuttings give evidence of the presence or absence of polyploid tissue in the centre of the chimaera. The number of divisions occurring in poor roots was increased by keeping the potted plant in the refrigerator for four days and then bringing it into a warm house for two days before fixing the root tips. Fixations made on warm sunny days of young expanding leaves also give chromosome counts indicative of the presence or absence of polyploid tissue in the outer tissues of a chimaerical plant.

Finally root tip counts on seedlings produced by chimaerical plants indicate by the presence or absence of triploids whether the reproduction layer of the plant contains tetraploid tissue or not.

These counts can be made on root tips obtained by germinating the seeds on damp filter paper, but owing to the losses caused by moulds to the slow germinating seeds it is preferable to germinate them in miniature soil blocks of seed compost 1 inch in diameter and 2 inches high. For chromosome counts, root tips and young leaf tissues were given a prefixation treatment of one hour in a saturated solution of α-bromonaphthalene in water, to contract the chromosomes and hold the divisions at metaphase, before being transferred to Bradley fixative (1 part glacial acetic acid, 4 parts chloroform, 3 parts absolute alcohol). Squash preparations were then made with acetic orcein. Time in searching root tips preparations was saved by squashing 1 mm. of the root tip under the coverglass and then spreading it by tapping with a needle point. In this way an orderly array of the tissues is obtained in which the areas containing dividing nuclei can be rapidly found. The separation and squashing of individual cells by this method is not quite so good as when the orthodox method of macerating with a bone handle is employed, but this is outweighed by the rapidity with which divisions can be examined.

(*c*) *Germination of Triploid Seeds*

During the summer of 1951 an experiment was made to germinate hop seeds out-of-season for the purpose of making chromosome counts in the root tips. A series of seeds was sown on 18th June in compost held in demountable aluminium containers fitted in a rack. The operculum of each seed had been opened with a flat needle. A number of the seeds germinated in about a fortnight and chromosome counts were made on their root tips. All were diploids. After another month two more seedlings appeared—one was diploid and the other triploid. In the following spring, between 10th March and 8th May, further seedlings grew up and were found to be mostly triploids.

This delayed germination of opened triploid seeds suggested that triploid seeds might remain viable longer than diploid ones. Hence in the spring of 1952 a large group of 2-year-old seeds, which had been obtained from open pollinated cones of a chimaerical plant, were sown in the normal way. A filter paper germination test of this seed when new had given three diploids/two triploids from 50 seeds. From 140 2-year-old seeds there grew 50 seedlings which were all triploid. These results show that triploid hop seed tends to germinate more slowly than diploid seed and to retain its viability longer.

Results to Date of Triploid Hop Breeding

At present we have no triploid plants produced by controlled crossing. In order to obtain information as rapidly as possible upon the behaviour of triploid hop plants, the triploid seedlings obtained by open pollination of chimaerical tetraploid plants of Bullion and Brewer's Gold hops were planted in the experimental garden in the early spring of 1952. Strong gales during the early summer caused severe damage to most of the plants, but despite this set-back, 16 plants managed to ripen a crop of hops.

The young plants were very much more even in appearance of their leaves and general growth during the seedling stage than is usual with a collection of diploid seedlings. The upper surface of the leaf developed a more convex bulge, the veins were less prominent and the upper surface felt more bristly in the triploids than in diploid seedlings. The bines of the triploid plants carried leaves of a darker blue-green hue than did those of diploids. One extremely dwarf triploid plant was discovered which never grew more than 3 inches high and had non-climbing stems.

At the end of the growing season the triploid plants in the garden varied in height from dwarfs of 2 feet to plants which had reached the top of the strings (about 15 feet). An analysis of the size differences would be unprofitable because some of the "half-dwarf" plants were undoubtedly the result of damage to the growing tips by the early season winds. This damage also resulted in a delayed ripening of the crop of cones on these plants.

All the plants which bore a well developed crop produced hops very closely resembling respectively Bullion and Brewer's Gold in size and appearance.

Table 2

Sex Expression in 3*n* Plants Derived by Open Pollination of 4*n* Bullion and 4*n* Brewers Gold Hops.

	No. of plants which are :			
	Female	Male + few cones	Male	Sterile dwarfs
ex Bullion ..	42	19	7	16
ex Brewer's Gold	2	2	0	4

The triploid plants showed most interesting variations in sex expression, with a very high percentage of plants bearing male flowers, as shown in Table 2.

A scheme of genetical sex determiners cannot be inferred from these sex ratios, because the seeds arose through fertilization by unknown males of possibly different genetical constitutions with regard to sex determination.

The high percentage of maleness shown by these progeny which each received two doses of genes from the female parent and only one from the male, may be a manifestation of the new numerical balance between genes which is generated in the triploid state. Or it may be connected with the fact that, in common with most of the Anglo-American hybrid hops, Bullion and Brewer's Gold both exhibit a little monoecism in some seasons. When triploid progenies are available from tetraploids of a completely female hop such as Fuggle, it should be possible to establish which of these factors is operating.

The Crop Harvested from the Triploid Seedlings

The cones were similar in size and type to those harvested from the control plants of Bullion and Brewer's Gold. There was some variation in time of ripening from early to late and the quantity of crop on individual plants varied from poor to good. The cones were well grown out and contained only very occasional seeds whose presence was shown by the outward bulge of the enveloping bracteole.

Acknowledgment

The author wishes to express his thanks to Mr. R. F. Farrar for his help with the experiments described in this paper.

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A SURVEY OF HOP-PICKING MACHINES, 1952

G. P. Chater
(*Hops Advisory Officer, West Midland Province, N.A.A.S.*)

A further survey of hop-picking machines was carried out in the West Midlands in 1952.

The machines surveyed were as follows:

Bruff machines	5 large, 2 medium, 2 type "B", 1 type "C".
McConnell-Hinds	1 Plucker Bank.
Composite	1 Bruff Picker mounted in a McConnell-Hinds Flying Finger.

The Strettle and Burr Picker and a roller type of picker were seen at work, but no comparable figures were obtained from these prototype machines.

Machine Alterations

On some of the older Bruff machines the roller lateral picker had been replaced by an arrangement whereby laterals were returned in bunches for picking in the lower end of the main picker. This was not considered a successful alteration and the rollers were re-inserted.

The Bruff type "B" is substantially the same as the Medium or "200" machine, except that at the feeding end a roller conveyor brings the broken laterals back to women for collection and insertion on the main string conveyor. The medium machine passes the laterals forward to the roller lateral picker placed in the centre of the machine.

Type "C" is smaller than the type "B".

The Composite machine was originally a McConnell-Hinds Flying Finger (1950). The picking mechanism was replaced by a horizontal type Bruff Picker but no other alterations were made to this machine.

Details of Survey

The procedure followed in 1951 (1) was adopted in 1952 with the following exceptions:

(*a*) The analysis of the final sample was divided into five instead of four parts. The Broken Hop of the sample was divided into two categories: (1) Broken Hop, i.e. hops with two or more petals missing. (2) Petal not attached to Hop Strig (Rachis), Hop Strig without any Petals attached and loose seed.

(*b*) Hops from the same trailer were not only specially hand picked but commercially picked by hand into a crib and samples from each method dried with a comparable machine picked sample in order to compare "Resin Content".

The average results of these analyses, stated as percentages, together with other data relevant to each machine, are given in tables at the end of this report.

Eight of the machines (A, B, D, E, F, G, H and K) studied in 1951 were included in the 1952 survey, and for these machines certain of the data obtained in 1951 are given in the tables to enable a comparison to be made between the two years.

Discussion

The climatic conditions experienced in 1952 caused the hops to develop into exceptionally large cones and at the same time to ripen unevenly, not only between different plants, but also among hops growing on the same bine. These conditions made it extremely difficult for both hand pickers and machines to avoid breakage of the cones and pick a high percentage of whole hops.

It was observed that, as compared with 1951, more care was taken in carting the strings from yard to machine and handling at the machine was generally simplified.

In some cases, an iron frame on a wooden platform had been fixed to the tractor, while in other cases this frame had been fixed to the trailer. The frame supported a grooved rail on each side, which in turn supported an iron bar, with wheels at each end. Each bar had six hooks welded on both sides and the strings were laid over the hooks until the bar was fully loaded. The bar was then pushed forward on the rails and another bar loaded. The complete load, of up to 12 bars, was then pushed on to a fixed rail conveyor at the machine.

It is interesting to note that the number of machines now working in the West Midlands has increased to a total of 60 and the acreage picked by machine in Worcestershire was approximately

36 per cent. of the total acreage grown, while in Herefordshire the acreage was approximately 24 per cent. of the total grown. Of the total acreage of hops grown in the West Midlands approximately 27 per cent. were picked by machine in 1952.

Conclusions

The figures attached to this report show that the extraneous matter in most machine picked samples was reduced to a very low figure. The observation that "the cleaner the sample the more the waste" still appears to be correct, although the total waste from the machine has not been computed.

The action of picking the hop, whether by hand or machine, appears to cause some loss of "Resin Content". The figures for commercially hand picked hops give the loss due to picking only, since these samples had not received the buffeting hand picked hops usually receive during measuring, carting, etc. As it is likely that some further loss of resins takes place due to the treatment the hops receive between picking and arrival on the drying floor, the figures for the resin content (Preservative Value) of the machine and hand picked samples are not strictly comparable and are biassed in favour of the latter. The figures confirm the general loss of Preservative Value as shown in 1951.

As there seems to be a general tendency for the standard of machine picking to improve during the season, until the hops begin to get over-ripe, this suggests that the optimum period for satisfactory picking is when the crop is fully ripe. This optimum period may be extended by growing a range of varieties which ripen at different stages through the season. Also, no doubt as machines are improved, they will be able to deal more efficiently with under-ripe hops.

The whole hop content, with a few exceptions, was found during the picking season to be lower in 1952 than in 1951, and this caused a number of experiments and innovations to be tried. It is probable that these will be reflected by improvements to both new and old machines in 1953.

Observations on the methods used to dry machine picked hops as compared with those used for hand picked hops, show that there are several fundamental differences. It seems possible that these vary according to the wholeness of the sample that reaches the Kiln Floor.

ACKNOWLEDGMENTS

Many thanks are due to the growers who so kindly and wholeheartedly co-operated in this survey, to the teams of Wye Students for their conscientious work, and to the Agricultural Research Council for their continued financial support.

REFERENCE

(1) GIBB, J. A. C. and CHATER G. P. "A Survey of Hop Picking Machines, 1951." *Department of Hop Research, Wye College, for* 1951.

ABBREVIATIONS USED IN TABLES

W.H.	Whole Hops.	
B.H.	Broken Hops. Any Hop with more than two petals missing.	
P and S.	Loose Petals, Hop Strig (Rachis) without Petals attached. Loose Seed.	
L.	Leaf, however small.	
St.	Leaf Stem (Petiole) and/or Hop Stem when more than 1" long.	
Sp. H.P.	Special Hand Picked Hops.	
Com. H.P.	Commercially Hand Picked Hops.	
Mach. P.	Machine Picked Hops.	
T.S.R.	Total Soft Resin	Calculated on "Moisture Free" Hops.
Alpha	Alpha Resin	

MEDIUM BRUFF

Machine A.

Analysis of Breakage

	1st Week		2nd Week		3rd Week	
	1952 Av. % Fuggle	1951 Av. % Fuggle	1952 Av. % Fuggle	1951 Av. % Fuggle	1952 Av. % Fuggle	1951 Av. % Fuggle
W.H.	36·3	45·1	29·2	47·0	23·0	43·0
B.H.	31·1	46·0	47·5	45·8	49·3	49·5
P & S	26·1		18·0		21·4	
L.	5·0	6·5	4·3	5·9	5·1	5·9
St.	1·0	2·25	0·8	1·3	0·8	1·5

Combined Waste

Hops in waste ..	14·0	9·1	17·9	9·0	18·5	23·8

10 Stripped Strings

Hops in waste ..	4·1	0·46	1·9	0·94	5·0	0·86

Special Hand Picked

Analysis of Total Weight

	1st Week	2nd Week	3rd Week
Hop ..	55·5	57·5	55·0
L. ..	23·5	20·5	23·5
St. ..	21·0	22·0	21·5

Commercial Hand Picked

Analysis of Breakage

W.H. ..	65·0	71·0	59·0
B.H. ..	30·0	24·0	37·0
P & S ..	1·7	3·2	3·2
L. ..	2·8	1·8	0·8
St. ..	0·4	—	—

Collection of Strings in Yard

Strings	70	72	75
Minutes	3	3	3¼

Rate of Feeding Strings

Per min.	10	10	10

Preservative Value

	Sp. H.P.	Com. H.P.	Mach. P.	Mach. P. Gain or Loss 1952	Mach. P. Gain or Loss 1951
1st Week					
T.S.R. %	13·43	11·08	10·80	−2·63	−1·8
Alpha %	5·38	4·55	3·96	−1·42	−0·69
2nd Week					
T.S.R. %	15·00	15·37	15·00	−Nil	−1·69
Alpha %	6·32	4·84	6·32	−Nil	−0·77
3rd Week					
T.S.R. %	14·13	13·46	11·29	−2·84	−1·37
Alpha %	4·96	4·84	4·07	−0·89	−0·67

Distance to Yard Centre

400-700 yards

Carrying Equipment

2 Tractors
3 Trailers

Method of Loading Strings

String pulled and laid over bar—surround fixed to trailer

Hopyard Labour

4 Persons and 2 Tractor Drivers

Labour on Machine

13 Persons on Machine
8 women picking laterals by hand

Production

Acreage picked	= 17
Dried cwt.	= 244
No. Hours worked	= 175
Picked per hour	= 1·4 cwt.
Hours per ton	= 14·3

MEDIUM BRUFF

Machine B.

Analysis of Breakage

	1st Week 1952 Av. % Fuggle	1st Week 1951 Av. % Fuggle	2nd Week 1952 Av. % Fuggle	2nd Week 1951 Av. % Fuggle	3rd Week 1952 Av. % Fuggle	3rd Week 1951 Av. % Fuggle
W.H.	29·5	49·1	35·5	46·2	65·0	42·0
B.H.	38·0	42·0	44·4	46·5	18·7	46·3
P & S	27·1		13·6		11·3	
L.	4·5	7·2	5·3	5·8	4·3	7·2
St.	0·9	1·6	1·0	1·5	0·7	2·4

Combined Waste

Hops in waste ..	11·65	4·25	8·1	6·8	11·8	8·1

10 Stripped Strings

Hops in waste ..	8·15	0·36	0·75	0·37	0·7	0·9

Special Hand Picked

Analysis of Total Weight

	1st Week	2nd Week	3rd Week
Hop ..	52·5	47·0	51·0
L. ..	24·0	27·0	23·0
St. ..	23·5	26·0	26·0

Commercial Hand Picked

Analysis of Breakage

W.H. ..	61·0	70·0	81·0
B.H. ..	25·0	18·0	13·7
P & S ..	4·1	3·9	3·0
L. ..	8·2	7·0	1·5
St. ..	1·5	0·8	0·8

Collection of Strings in Yard

Strings	86	119	125
Minutes	11	9¼	9¼

Rate of Feeding Strings

Per min.	9	9	9–10

Preservative Value

	Sp. H.P.	Com. H.P.	Mach. P.	Mach. P. Gain or Loss 1952	Mach. P. Gain or Loss 1951
1st Week					
T.S.R. %	10·96	10·98	9·89	−1·07	−0·6
Alpha %	4·19	4·21	3·48	−0·71	−1·19
2nd Week					
T.S.R. %	13·18	11·20	9·76	−3·42	−0·85
Alpha %	5·04	4·20	3·03	−2·01	−0·75
3rd Week					
T.S.R. %	11·84	11·32	11·50	−0·34	−1·79
Alpha %	4·61	4·57	4·00	−0·61	−1·47

Distance to Yard Centre

500–1,200 yards

Carrying Equipment

2 Tractors
3 Trailers

Method of Loading Strings

Strings laid lengthways on two-wheeled trailer. Unloaded at machine by tipping off trailer

Hopyard Labour

4 Persons and 2 Tractor Drivers

Labour on Machine

20 Persons

Production

Acreage picked	= 20·2
Dried cwt.	= 302
Machine hours	= 169
Picked per hour	= 1·7 cwt.
Hours per ton	= 11·1

Machine D.

Analysis of Breakage

	1st Week 1952 Av. % Fuggle	1st Week 1951 Av. % Fuggle	2nd Week 1952 Av. % Fuggle	2nd Week 1951 Av. % Fuggle	3rd Week 1952 Av. % Fuggle	3rd Week 1951 Av. % Fuggle
W.H.	29·7	45·2	31·8	42·3	27·4	48·3
B.H.	40·5	47·1	38·9	49·7	36·6	41·9
P & S	23·0		22·1		29·7	
L.	5·6	6·7	6·1	6·9	5·4	7·8
St.	0·8	0·9	0·8	1·1	0·7	2·0

Combined Waste

Hops in waste ..	12·8	7·8	13·6	20·3	13·8	14·9

10 Stripped Strings

Hops in waste ..	3·1	0·8	2·8	0·5	0·8	1·4

Special Hand Picked

Analysis of Total Weight

	1st Week	2nd Week	3rd Week
Hop ..	61·2	45·5	53·2
L. ..	17·2	24·2	21·4
St. ..	21·5	30·2	25·4

Commercial Hand Picked

Analysis of Breakage

W.H. ..	66·0	73·2	76·0
B.H. ..	30·8	18·0	16·6
P & S ..	1·6	3·4	3·1
L. ..	1·1	4·1	1·2
St. ..	0·5	1·3	1·2

Collection of Strings in Yard

Strings	114	72	118
Minutes	14½	14	13¼

Rate of Feeding Strings

Per Min.	7·8	8	8

Preservative Value

	Sp. H.P.	Com. H.P.	Mach. P.	Mach. P. Gain or Loss 1952	Mach. P. Gain or Loss 1951
1st Week					
T.S.R. %	12·00	11·41	9·29	−2·70	−2·53
Apha %	4·80	4·27	2·80	−2·10	−1·06
2nd Week					
T.S.R. %	14·00	12·99	10·96	−3·04	−0·93
Alpha ..	5·84	5·54	3·77	−2·07	−0·38
3rd Week					
T.S.R. %	13·52	12·35	13·42	−0·10	−1·53
Alpha %	5·52	4·91	3·89	−1·63	−1·30

Distance to Yard Centre

600 yards

Carrying Equipment

3 Tractors fitted with overhead frames

Method of Loading Strings

Frame, mounted on Tractor, carrying wheeled bars on which 12 hooks had been welded. String pulled and placed over hook. Bars unloaded on to Permanent Feeding Frame

Hopyard Labour

7 Persons and 3 Tractor Drivers

Labour on Machine

20 Persons

Production

Acreage picked	= 22
Dried cwt.	= 240
Machine hours	= 100
Picked per hour	= 2·4 cwt.
Hours per ton	= 8·3

LARGE BRUFF

Machine E.

Analysis of Breakage

	1st Week		2nd Week		3rd Week	
	1952 Av. % Fuggle	1951 Av. % Fuggle	1952 Av. % Fuggle	1951 Av. % Fuggle	1952 Av. % Fuggle	1951 Av. % Fuggle
W.H.	28·1	52·5	33·8	46·0	36·5	45·7
B.H.	48·7	41·0	40·1	43·5	35·8	45·1
P & S	16·6		19·0		20·6	
L.	5·4	5·6	6·1	8·1	6·5	7·2
St.	0·8	0·9	0·5	2·3	0·5	2·0

Combined Waste

Hops in waste ..	21·2	21·0	14·3	15·2	19·7	15·0

10 Stripped Strings

Hops in waste ..	2·6	3·0	3·9	2·2	3·1	2·0

Special Hand Picked

Analysis of Total Weight

	1st Week	2nd Week	3rd Week
Hop ..	60·0	55·9	55·5
L. ..	8·4	20·2	20·5
St. ..	31·6	23·7	24·0

Commercial Hand Picked

Analysis of Breakage

W.H. ..	69·0	71·4	73·0
B.H. ..	19·5	17·4	19·3
P & S ..	2·4	2·7	2·7
L. ..	7·3	7·5	4·0
St. ..	1·6	0·9	0·9

Collection of Strings in Yard

Strings	160	160	160
Minutes	9	9¼	9

Rate of Feeding Strings

Per Min.	13	12	12

Preservative Value

	Sp. H.P.	Com. M.P.	Mach. P.	Mach. P. Gain or Loss 1952	Mach. P. Gain or Loss 1951
1st Week					
T.S.R. %	15·73	11·29	10·76	−4·97	−3·73
Alpha %	6·05	4·53	3·79	−2·26	−1·10
2nd Week					
T.S.R. %	14·45	12·90	12·62	−1·83	−1·26
Alpha %	4·54	4·85	4·50	−0·04	−0·81
3rd Week					
T.S.R. %	12·93	12·26	10·36	−2·57	−2·49
Alpha %	5·84	4·88	3·92	−1·92	−1·75

Distance to Yard Centre

550 yards

Carrying Equipment

3 Tractors
5 Trailers

Method of Loading Strings

String pulled and twisted on trailer leaving base on top of ball. Two men load one trailer

Hopyard Labour

6 Persons and 3 Tractor Drivers

Labour on Machine

17 Persons

Production

Acreage picked	= 27
Dried cwt.	=333
Machine hours	=132
Picked per hour	=2·5 cwt.
Hours per ton	=7·9

LARGE BRUFF

Machine F.

	Analysis of Breakage					
	1st Week		2nd Week		3rd Week	
	1952 Av. % Fuggle	1951 Av. % Fuggle	1952 Av. % Fuggle	1951 Av. % Fuggle	1952 Av. % Fuggle	1951 Av. % Fuggle
W.H.	32·1	39·0	62·2	43·5	41·9	41·0
B.H.	45·1	52·5	21·0	51·7	31·8	52·0
P & S	16·5		9·8		20·7	
L.	5·6	6·2	4·7	3·6	4·5	4·8
St.	0·6	2·2	2·2	1·2	1·0	2·2
Combined Waste						
Hops in waste	21·5	9·4	23·6	9·5	13·7	7·9
10 Stripped Strings						
Hops in waste	0·9	2·5	1·1	0·5	1·1	1·3

Special Hand Picked

Analysis of Total Weight

	1st Week	2nd Week	3rd Week
Hop	58·0	55·0	54·0
L.	18·5	20·0	21·0
St.	23·5	25·0	25·0

Commercial Hand Picked

Analysis of Breakage

W.H.	81·0	79·5	75·0
B.H.	10·7	8·5	15·8
P & S	3·3	0·9	2·5
L.	4·0	8·5	4·9
St.	0·6	2·5	1·5

Collection of Strings in Yard

Strings	89	82	92
Minutes	6½	5¾	6¾

Rate of Feeding Strings

Per min.	12	11	10–14

Preservative Value

	Sp. H.P.	Com. H.P.	Mach. P.	Mach. P. Gain or Loss 1952	1951
1st Week					
T.S.R. %	13·11	12·15	11·17	−1·94	−0·89
Alpha %	5·28	4·70	3·88	−1·40	−0·87
2nd Week					
T.S.R. %	12·50	8·70	9·80	−2·70	−1·05
Alpha %	6·16	4·83	4·90	−1·26	−0·88
3rd Week					
T.S.R. %	15·36	13·76	12·16	−3·20	−0·12
Alpha %	6·23	4·79	2·32	−3·91	−0·74

Distance to Yard Centre

600–900 yards

Carrying Equipment

3 Tractors
4 Light 2-wheeled Trailers

Method of Loading Strings

Strings pulled and laid lengthwise on shallow trailer.

Hopyard Labour

2 Men and 3 Tractor Drivers

Labour on Machine

19 Persons

Production

Acreage picked	= 37
Dried cwt.	= 531
Machine hours	= 198
Picked per hour	= 2·6 cwt.
Hours per ton	= 7·4

LARGE BRUFF

Machine G.

Analysis of Breakage

	1st Week		2nd Week		3rd Week	
	1952 Av. % Fuggle	1951 Av. % Fuggle	1952 Av. % Fuggle	1951 Av. % Fuggle	1952 Av. % Fuggle	1951 Av. % Fuggle
W.H.	18·7	58·5	21·7	38·1	29·9	56·3
B.H.	46·1	30·6	43·5	48·4	46·0	35·5
P & S	26·1		25·2		19·4	
L.	6·7	8·8	8·5	11·0	5·8	6·7
St.	2·2	2·1	0·8	2·4	1·3	1·5

Combined Waste

Hops in waste	21·3	10·0	15·5	7·2	22·4	8·3

10 Stripped Strings

Hops in waste	9·3	5·4	5·5	1·9	6·2	1·2

Special Hand Picked

Analysis of Total Weight

	1st Week	2nd Week	3rd Week
Hop	42·0	51·0	54·5
L.	32·5	29·0	25·0
St.	25·5	20·0	20·5

Commercial Hand Picked

Analysis of Breakage

W.H.	62·0	66·0	54·0
B.H.	31·5	27·5	40·5
P & S	1·7	3·8	4·7
L.	3·4	2·1	0·7
St.	1·4	0·6	—

Rate of Feeding Strings

Per Min.	9–11	12	7

Collection of Strings in Yard

Strings	75	75	75
Minutes	4¼	4	4½

Preservative Value

	Sp. H.P.	Com. H.P.	Mach. P.	Mach. P. Gain or Loss 1952	Mach. P. Gain or Loss 1951
1st Week					
T.S.R. %	13·40	12·59	10·50	−2·90	−0·79
Alpha %	5·01	4·24	3·39	−1·62	−1·10
2nd Week					
T.S.R. %	13·11	13·29	9·30	−3·81	−1·90
Alpha %	5·30	4·88	3·07	−2·23	−1·45
3rd Week					
T.S.R. %	14·66	14·46	10·08	−4·58	−1·93
Alpha %	4·99	4·64	3·53	−1·46	−1·02

Distance to Yard Centre

450–750 yards

Carrying Equipment

3 Tractors
3 Trailers

Method of Loading Strings

Fixed central bar with large hooks each side. Strings pulled and laid over hooks. Several strings per hook

Hopyard Labour

3 Men and 3 Tractor Drivers

Labour on Machine

26 Persons

Production

Acreage picked	= 27
Dried cwt.	=430
Machine hours	=192½
Picked per hour	=2·2 cwt.
Hours per ton	=8·9

LARGE BRUFF

Machine H.

Analysis of Breakage

	1st Week 1952 Av. % Fuggle	1st Week 1951 Av. % Fuggle	2nd Week 1952 Av. % Fuggle	2nd Week 1951 Av. % Fuggle	3rd Week 1952 Av. % Fuggle	3rd Week 1951 Av. % Fuggle
W.H.	26·5	52·8	34·5	58·9	54·8	68·3
B.H.	45·0	40·0	39·6	36·4	31·1	27·7
P & S	21·8		19·4		9·1	
L.	5·1	4·9	4·9	2·1	3·4	2·8
St.	1·1	2·3	1·2	2·6	1·5	1·2

Combined Waste

Hops in Waste ..	19·3	13·0	22	20·1	20·1	15·4

10 Stripped Strings

Hops in Waste ..	5·4	3·0	9·0	3·0	9·2	3·6

Special Hand Picked

Analysis of Total Weight

	1st Week	2nd Week	3rd Week
Hop ..	48·5	53·8	62·0
L. ..	26·25	20·5	16·5
St. ..	25·0	25·5	21·5

Commercial Hand Picked

Analysis of Breakage

W.H. ..	65·5	73·0	84·0
B.H. ..	29·3	22·5	12·5
P & S ..	2·9	1·9	1·3
L. ..	1·2	1·6	0·8
St. ..	0·6	0·8	1·3

Collection of Strings in Yard

Strings	144	144	144
Minutes	17	17¼	17

Rate of Feeding Strings

Per Min.	10	10	10

Preservative Value

	Sp. H.P.	Com. H P.	Mach. P.	Mach. P. Gain or Loss 1952	Mach. P. Gain or Loss 1951
1st Week					
T.S.R. %	15·51	15·36	12·01	−2·50	−2·28
Alpha %	6·92	6·58	6·49	−0·43	−1·18
2nd Week					
T.S.R. %	15·55	14·90	13·69	−1·86	−1·72
Alpha %	6·95	6·46	5·54	−1·41	−0·75
3rd Week					
T.S.R. %	16·59	17·21	17·01	+0·42	−2·24
Alpha %	7·86	6·77	6·29	−1·57	−0·78

Distance to Yard Centre

300–500 yards

Carrying Equipment

2 Tractors
5 Trailers

Method of Loading Strings

3 Trailers with fixed frames carrying wheeled bars with 12 hooks welded. String pulled and laid over hook. 2 flat trailers, strings laid lengthways.

Hopyard Labour

8 Persons and 2 Tractor Drivers

Labour on Machine

29 Persons

Production

Acreage picked	= 30
Dried cwt.	=567
No. Machine hours	=217
Picked per hour	=2·6 cwt.
Hours per ton	=7·6

McCONNELL-HINDS. PLUCKER BANK

Machine K.

Analysis of Breakage

	1st Week		2nd Week		3rd Week	
	1952 Av. % Fuggle	1951 Av. % Fuggle	1952 Av. % Fuggle	1951 Av. % Fuggle	1952 Av. % Fuggle	1951 Av. % Fuggle
W.H.	44·5	54·7	53·4	59·3	46·5	63·5
B.H.	33·0	39·3	29·3	33·2	25·2	30·7
P & S	13·5		10·8		21·6	
L.	6·1	4·2	5·1	4·4	5·1	3·2
St.	2·6	1·8	1·2	3·1	1·4	2·6

Lateral Waste

Hops in Waste ..	14·7	10·0	5·8	10·0	11·3	4·2

Leaf Waste

Hops in Waste ..	6·0	8·4	7·9	10·0	12·1	5·6

10 Stripped Strings

Hops in Waste ..	1·5	0·8	1·2	0·55	0·6	0·29

Special Hand Picked

Analysis of Total Weight

	1st Week	2nd Week	3rd Week
Hop ..	44·0	61·7	46·0
L. ..	30·8	20·6	30·5
St. ..	25·2	17·7	23·5

Commercial Hand Picked

Analysis of Breakage

W.H. ..	44·5	74·0	76·0
B.H. ..	50·0	21·0	15·1
P & S ..	2·3	3·2	3·0
L. ..	1·5	1·2	5·2
St. ..	1·5	0·6	0·7

Collection of Strings in Yard

Strings	104	95	127
Minutes	9	6½	7

Rate of Feeding Strings

Per Min.	8 per bank	8 per bank	8 per bank

Preservative Value

	Sp. H.P.	Com. H.P.	Mach. P.	Mach. P. Gain or Loss 1952	Mach. P. Gain or Loss 1951
1st Week					
T.S.R. %	13·56	10·59	10·03	−3·53	−0·84
Alpha %	4·91	3·60	4·07	−0·84	−0·27
2nd Week					
T.S.R. %	12·65	11·95	9·92	−2·73	+0·24
Alpha %	4·98	4·80	3·72	−1·26	−0·09
3rd Week					
T.S.R. %	10·35	10·56	6·53	−3·82	−1·12
Alpha %	5·41	5·10	4·22	−1·19	−0·04

Distance to Yard Centre

400–600 yards

Carrying Equipment

3 Tractors
3 Trailers

Method of Loading Strings

2 Men on each trailer. Pull strings so they fall lengthways on sheet covering bottom of trailer. Sheet and load pulled off trailer at machine

Hopyard Labour

5 Persons and 3 Tractor Drivers

Labour on Machine

35 Persons

Production

Acreage picked	= 39
Dried cwt.	=632½
No. Machine hours	=179
Picked per hour	=3·5 cwt.
Hours per ton	=5·6

BRUFF MODEL "B"

Machine M.

Analysis of Breakage

	1st Week Av. % Fuggle	2nd Week Av. % Fuggle	3rd Week Av. % Fuggle
W.H. ..	20·4	32·8	43·3
B.H. ..	42·4	41·9	32·6
P & S ..	25·9	19·6	17·5
L. ..	9·4	5·3	5·3
St. ..	1·9	0·2	0·8

Combined Waste

Hops in Waste ..	4·9	17·6	16·3

10 Stripped Strings

Hops in Waste ..	7·4	2·0	2·7

Special Hand Picked

Analysis of Total Weight

Hop ..	49·0	54·0	44·0
L. ..	22·75	25·5	30·0
St. ..	27·75	20·5	26·0

Commercial Hand Picked

Analysis of Breakage

W.H. ..	49·0	74·0	57·8
B.H. ..	46·0	18·25	30·5
P & S ..	2·1	2·5	4·7
L. ..	2·1	4·6	5·4
St. ..	0·7	0·65	1·3

Collection of Strings in Yard

Strings	144	92	110
Minutes	28½	11½	9½

Rate of Feeding Strings

Per Min.	9	12	12

Preservative Value

	Sp. H.P.	Com. H.P.	Mach. P.	Mach. P. Gain or Loss 1952
1st Week				
T.S.R. %	12·32	11·42	10·65	−1·67
Alpha %	4·91	4·21	3·79	−1·12
2nd Week				
T.S.R. %	11·48	10·06	9·15	−2·33
Alpha %	4·15	4·10	3·49	−0·66
3rd Week				
T.S.R. %	12·99	11·14	9·15	−3·44
Alpha %	5·17	4·09	3·13	−2·04

Distance to Yard Centre

120–200 yards

Carrying Equipment

2 Tractors with frames attached

Method of Loading Strings

Bars, with wheels each end, running in grooves of frame attached to tractor. Bars have six hooks each side. String cut from wire and laid on hook. Bars unloaded on to permanent frame at machine

Hopyard Labour

5 Persons and 2 Tractor Drivers

Labour on Machine

21 Persons

Production

Acreage picked	= 25
Dried cwt.	= 328
No. Machine hours	= 185
Picked per hour	= 1·7 cwt.
Hours per ton (Dry)	= 11·2

Machine N.

Analysis of Breakage

	1st Week Av. % Fuggle	2nd Week Av. % Fuggle	3rd Week Av. % Fuggle
W.H. ..	8·9	15·2	30·5
B.H. ..	48·5	43·7	39·5
P & S ..	31·0	27·9	22·3
L. ..	9·9	11·6	6·3
St. ..	1·0	1·0	0·6

Combined Waste

Hops in Waste ..	19·0	2·25	11·5

10 Stripped Strings

Hops in Waste ..	4·8	3·3	2·2

Special Hand Picked

Analysis of Total Weight

Hop ..	51·8	44·0	44·0
L. ..	25·8	32·0	29·0
St. ..	22·2	24·0	27·0

Commercial Hand Picked

Analysis of Breakage

W.H. ..	57·0	47·5	55·0
B.H. ..	36·9	39·5	33·5
P & S ..	2·7	8·5	4·7
L. ..	2·7	2·8	5·3
St. ..	0·7	1·5	1·5

Collection of Strings in Yard

Strings	84	84	84
Minutes	9	9	9

Rate of Feeding Strings

Per Min.	7	7	7

Preservative Value

	Sp. H.P.	Com. H.P.	Mach. P.	Mach. P. Gain or Loss 1952
1st Week				
T.S.R. %	11·71	12·81	10·70	−1·01
Alpha %	4·23	4·61	2·74	−1·49
2nd Week				
T.S.R. %	11·74	12·40	9·43	−2·31
Alpha %	4·27	4·40	1·84	−2·43
3rd Week				
T.S.R. %	13·80	12·35	11·26	−2·54
Alpha %	5·29	4·67	3·96	−1·33

Distance to Yard Centre

100–200 yards

Carrying Equipment

2 Tractors
2 Trailers with frame attached

Method of Loading Strings

Bars with wheels each end, running in grooves of frame attached to trailer. Bars have six hooks each side. String pulled from wire and laid over hook. Loaded Bars run on to Permanent Frame at machine

Hopyard Labour

6 Persons and 2 Tractor Drivers

Labour on Machine

20 Persons

Production

Acreage picked	= 16¾
Dried cwt.	= 328
No. Machine hours	= 178
Picked per hour	= 1·8 cwt.
Hours per ton (Dry)	= 10·8

Machine O.

Analysis of Breakage

	1st Week Av. % Fuggle	2nd Week Av. % Fuggle
W.H. ..	27·6	47·8
B.H. ..	30·2	22·9
P & S ..	33·4	23·1
L. ..	8·4	5·3
St. ..	0·2	0·6

Combined Waste

Hops in Waste ..	20·0	13·5

10 Stripped Strings

Hops in Waste ..	1·9	1·6

Special Hand Picked

Analysis of Total Weight

Hop ..	45·0	49·0
L. ..	28·0	20·8
St. ..	27·0	30·0

Commercial Hand Picked

Analysis of Breakage

W.H. ..	83·8	62·0
B.H. ..	12·0	28·0
P & S ..	1·8	5·2
L. ..	1·2	3·9
St. ..	1·2	0·9

Collection of Strings in Yard

Strings ..	175	120
Minutes ..	43	27

Rate of Feeding Strings

Per Min. ..	6·0	6·7

Preservative Value

	Sp. H.P.	Com. H.P.	Mach. P.	Mach. P. Gain or Loss 1952
1st Week				
T.S.R. %	14·76	11·23	10·69	−4·07
Alpha %	5·44	4·90	4·18	−1·26
2nd Week				
T.S.R. %	13·74	13·10	12·86	−0·88
Alpha %	5·43	4·98	4·72	−0·71

Distance to Yard Centre

500–1,000 yards

Carrying Equipment

1 Tractor
2 Trailers

Method of Loading Strings

Strings pulled and laid on stationary trailer. Trailer load tipped off on to ground at machine

Hopyard Labour

3 Persons and 1 Tractor Driver

Labour on Machine

14 Persons

Production

Acreage picked	= 12
Dried cwt.	=145
Machine hours	=196
Picked per hour	=0·7 cwt.
Hours per ton	= 28

COMPOSITE MACHINE (McCONNELL-HINDS—BRUFF)

Machine P.

Analysis of Breakage

	1st Week Fuggle	2nd Week Fuggle	3rd Week Fuggle
W.H. ..	20·6	21·5	15·8
B.H. ..	44·9	44·0	50·7
P & S ..	27·0	23·3	24·2
L. ..	5·8	9·3	7·6
St. ..	1·4	1·6	1·4

Combined Waste

Hops in Waste ..	7·4	7·2	12·7

10 Stripped Strings

Hops in Waste ..	5·0	2·5	3·2

Special Hand Picked

Analysis of Total Weight

Hop ..	50·0	40·5	49·0
L. ..	20·2	34·5	24·0
St. ..	29·7	25·0	27·0

Commercial Hand Picked

Analysis of Breakage

W.H. ..	49·0	58·0	60·0
B.H. ..	35·5	27·7	35·0
P & S ..	3·6	4·7	0·9
L. ..	9·1	7·2	3·0
St. ..	2·7	2·0	1·0

Collection of Strings in Yard

Strings	460	450	425
Minutes	14	15	14

Rate of Feeding Strings

Per Min.	14·15	12·0	15·16

Preservative Value

	Sp. H.P.	Com. H.P.	Mach. P.	Mach. P. Gain or Loss 1952
1st Week				
T.S.R. %	13·80	10·99	8·17	—5·73
Alpha %	5·29	3·94	3·59	—1·70
2nd Week				
T.S.R. %	13·72	13·00	14·46	+0·74
Alpha %	5·44	4·71	3·86	—1·78
3rd Week				
T.S.R. %	11·85	10·80	10·75	—1·10
Alpha %	4·94	4·55	4·68	—0·26

Distance to Yard Centre

500 yards–3 miles

Carrying Equipment

3 Tractors
8 Trailers

Method of Loading Strings

1 Tractor with 2 Trailers 1 Man pulling and dropping string lengthways in each Trailer

Hopyard Labour

8 Persons and 3 Tractor Drivers

Labour on Machine

38 Persons

Production

Acreage picked	= 55
Dried cwt.	=750
No. Machine hours	=199
Picked per hour	=3·8 cwt.
Hours per ton	=5·3

A NOTE ON THE ESTIMATION OF PEROXIDASE IN HOPS

A. R. Tatchell

The oxidation by enzymes of the resinous constituents of the hop during storage was a possibility considered by Heron (1922) and Burgess (1935), but in the absence of a suitable method of estimation no definite experimental evidence could be obtained. Recently in this Department, it was shown qualitatively that a peroxidase was present in the hop cone and it was considered desirable to study methods for its quantitative estimation. With such a method it was hoped to follow the peroxidase content of green hops during ripening and the subsequent variation during drying and storing.

The standard method of Willstätter and Stoll (1918) using pyrogallol as the acceptor and estimating colorimetrically the amount of the purpurogallin formed, was shown to be unsuitable owing to the lower peroxidase content of the hop as compared with, say, horse-radish. A new method using o-phenylene diamine as the acceptor, developed in the Wallerstein Laboratories for the estimation of the peroxidase activity of potatoes (1947) and malt (1948), seemed promising and this method was examined in detail.

The Wallerstein workers, although stating that the product formed during the reaction was a phenazine compound did not complete its identification, but Chodat (1925) had previously recorded that the action of peroxidase and hydrogen peroxide on o-phenylene diamine gave 2:3 diaminophenazine. It is now known that when using aqueous extracts of horse-radish, green hops or dry hops, 2:3 diaminophenazine is formed almost exclusively.

Early experiments indicated that the method used by the Wallerstein workers (1948) would need modification to suit the individual requirements of the hop. It was, therefore, necessary to examine the effect of substrate (H_2O_2) concentration, acceptor (o-phenylene diamine) concentration, temperature and pH on the initial velocity of formation of 2:3 diaminophenazine, and thus to establish the optimum conditions which would give rise to maximum activity.

These investigations were carried out on filtered aqueous extracts of green or dried hops, or horse-radish. The hop extracts were prepared by shaking 10 g. of minced green or dried hops with water (900 ml.) plus 2M acetate buffer (20 ml.); in the case of horse-radish 1 g. of the minced root was shaken with water (900 ml.) plus 2M acetate buffer (20 ml.). Unless otherwise stated the buffer solution was at pH 4·48. The amount of 2:3 diaminophenazine formed was determined colorimetrically measuring the transmittance on the Spekker photo-electric absorptiometer; a standard calibration curve was prepared using pure 2:3 diaminophenazine.

Substrate Concentration

The effect of varying concentrations of hydrogen peroxide on the initial velocity of formation of 2:3 diaminophenazine was studied at three different concentrations of o-phenylene diamine. The results found are given in Table 1, while Fig. 1 shows typical curves obtained using green hop extracts; similar curves were obtained with both dried hop and horse-radish extracts.

Table 1

Maximum velocities of formation of 2:3 diaminophenazine for optimum hydrogen peroxide concentrations at different concentrations of o-phenylene diamine.

Extract	Acceptor concentration %	Optimum molar concentrations ($H_2O_2 \times 10^{-3}$)	Maximum velocity (dx/dt)*
Green Hop ..	0·1	11·20	9·70
	0·05	7·95	5·10
	0·025	3·98	2·80
Horse-radish	0·1	20·00	16·70
	0·05	11·70	6·25
	0·025	7·95	2·80
Dried Hop ..	0·3	15·80	10·10
	0·15	11·70	5·70
	0·075	8·91	2·90

* dx/dt is the slope, at zero time, of the curve relating concentration of 2:3 diaminophenazine with time (in minutes), and represents the initial rate of formation of 2:3 diaminophenazine.

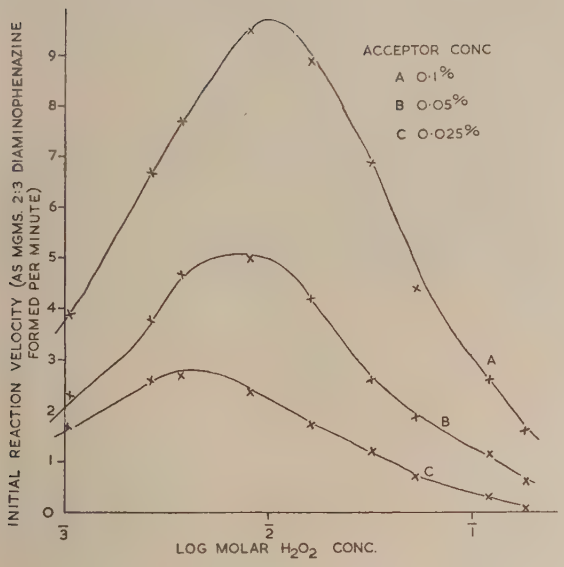

FIG. 1. Effect of H_2O_2 on Initial Reaction Variety.

The two main conclusions arising from these results are:

(1) For any given acceptor concentration, the greater the activity of the extract the higher will be the optimum hydrogen peroxide concentration.

(2) The optimum hydrogen peroxide concentration may be raised by increasing the acceptor concentration.

These conclusions are similar to those found by Willstätter and Weber (1926) and Mann (1931) when working with horse-radish peroxidase and using leuco-malachite green and guiacol. Furthermore, they emphasize the need to refer to both the acceptor and substrate concentrations when considering optimum conditions for the reaction.

Acceptor Concentration

Different concentrations of o-phenylene diamine were used at three concentrations of hydrogen peroxide. Fig. 2 shows the results obtained with dried hop extracts.

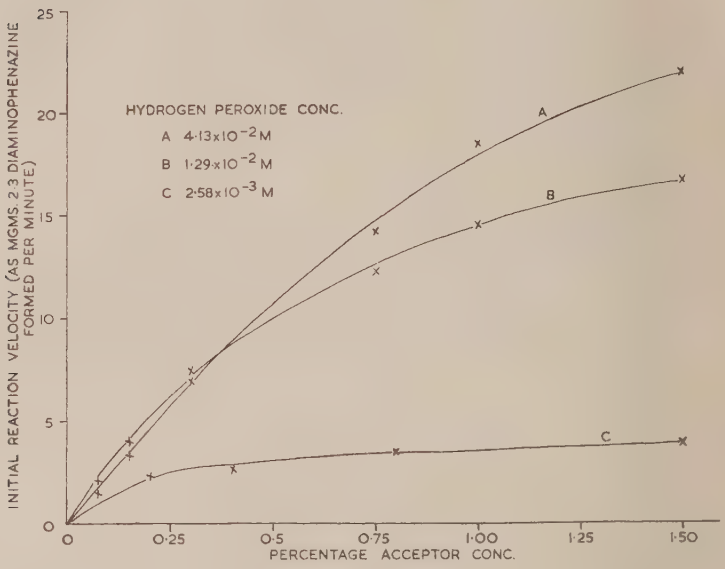

Fig. 2. Effect of Acceptor Concentration on Initial Reaction Velocity.

The main difficulty in these experiments was to prevent the reaction proceeding so rapidly as to make the measurements inaccurate. This could best be achieved, in the case of the more active preparations from horse-radish or green hops, by using very small concentrations of hydrogen peroxide (approx. $1{\cdot}47\times10^{-3}$M) so that at the highest concentration of o-phenylene diamine (3 per cent.) the velocity was measurable with reasonable accuracy. Concentrations of o-phenylene diamine higher than this could not be used, the solubility of the compound being the limiting factor. It was found, however, that in the case of horse-radish or green hop extracts there was a small but significant inhibition of the reaction at the highest concentration of o-phenylene diamine.

Temperature and Time

The effect of temperature on the peroxidase was studied by heating the aqueous extract of dried hops to the required temperature, maintaining it at this level for two minutes and then returning it to room temperature. Standard amounts of o-phenylene diamine (10 ml. of a 1 per cent. aqueous solution) and of hydrogen peroxide (2 ml. of a 2 per cent. solution) were then added and the solutions stood for 90 minutes before reading the transmittance on the Spekker. Ninety minutes was chosen because after this time interval it was found that the reaction had reached a more or less steady state.

Fig. 3 shows the results obtained and indicates that extensive inactivation does not occur until about 60° C. is reached.

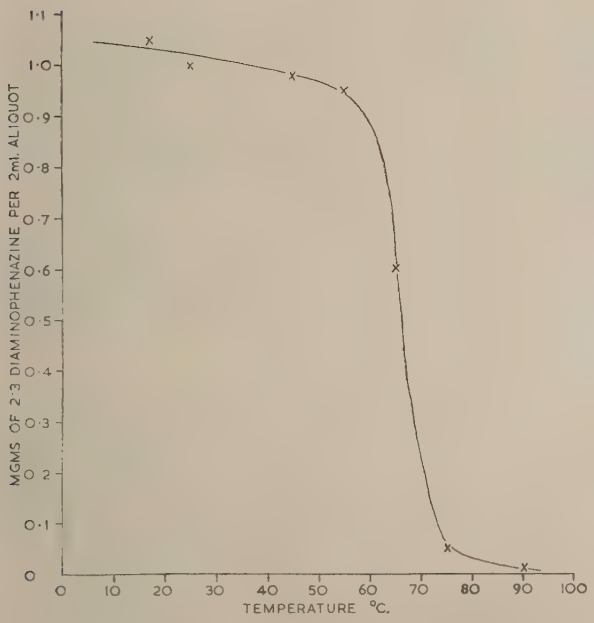

Fig. 3. Effect of Temperature on Peroxidase.

pH

Difficulty was experienced with these experiments because of the precipitation of 2:3 diaminophenazine in the pH range 5·5-6·5, and also because in this region certain steps in the reaction seem to be inhibited. This results in brown green colorations developing in the early stages, instead of the usual black-red. It would appear that the maximum initial velocity of the reaction is reached in the region of pH 5·5. Although the experiments described above were carried out at pH 4·48 the amount of 2:3 diaminophenazine formed initially was never sufficient to cause precipitation. In the analysis of hop samples, in which the solutions are stood for standard time (90 minutes), the amount of 2:3 diaminophenazine formed might well exceed the limiting concentration and to safeguard against this the pH was lowered to 4·26. Other workers using o-phenylene diamine and determining the optical density, after a given time, on a Klett colorimeter, found that maximum activity occurred at pH 4·5.

Method of Peroxidase Analysis

From a consideration of the above results, a method of analysis has been developed embodying the following points:

(1) In order to cover the optimum hydrogen peroxide concentration, not less than four determinations should be made on one sample, each one containing different amounts of hydrogen peroxide.

(2) The o-phenylene diamine concentration should be constant; a convenient amount is 0·1 per cent.

(3) The extracts should be buffered at about pH 4·26.

(4) The extracts, after the addition of o-phenylene diamine and hydrogen peroxide, should be stood for a standard time (90 minutes) when a more or less steady state has been reached and the solutions can be sampled accurately.

The method finally adopted, which has been found satisfactory for determining the peroxidase content of hops, is as follows:

Four minced samples (1 g.) are separately shaken with water (90 ml.) and 2M acetate buffer (2 ml. at pH 4·26) for fifteen minutes. After filtering, 1 per cent. aqueous o-phenylene diamine (10 ml.) is added to each of the four filtrates followed by 2 per cent. hydrogen peroxide (0·5, 1·0, 1·5, 2·0 ml.; or 1·0-2·5 ml., etc.) according to peroxidase content. After standing in the dark for 90 minutes four 1 ml. aliquots (one from each sample) are added separately into acetone (4 × 10 ml.). The acetone solutions are then filtered into glass cells and the transmittance read in the usual manner on the

Spekker photo-electric absorptiometer (setting 1 for acetone; Ilford filters No. 602). The four results are then plotted (drum reading/ml. H_2O_2) the peak giving the maximum drum reading at optimum hydrogen peroxide concentration. Reference to a standard curve prepared from pure synthetic 2:3 diaminophenazine then gives the amount of this compound formed.

Peroxidase Content of Green and Stored Hops

The peroxidase content of green hops increases very rapidly during the early part of the ripening period but more slowly towards its end. The peroxidase contents of the varieties Northern Brewer, Brewer's Gold, Sunshine, Early Promise and Pride of Kent seem to be very similar, the total amount varying with the time at which they are picked.

It was found that during drying the peroxidase content decreased by amounts ranging from 56-78 per cent. according to variety.

In the course of investigations of humulone deterioration in stored hops (see p. 14), a study was made of the variation of peroxidase content of such hops, which has led to the following conclusions:

(1) Deterioration of humulone will proceed where the peroxidase has been completely inactivated by steaming, or partially inactivated by treatment with hydrogen sulphide or formaldehyde.

(2) Where the hops are stored in nitrogen, the peroxidase content remains practically unaltered. Storage in oxygen accelerates the reduction of peroxidase in the hop.

It would appear that the peroxidase content of hops can vary independently of the deterioration of humulone, and may be affected differently by conditions of storage.

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THE CHALLENGE CUPS FOR NEW VARIETIES OF HOPS

Professor E. S. Salmon

This Competition is now divided into three Classes: (1) The Brewers' Cup, for hops intended as substitutes for American hops; this Challenge Cup was offered in 1944 by Messrs. Barclay, Perkins, Messrs Guinness and Messrs. Whitbread; (2) the Growers' Cup, for hops intended to augment English commercial varieties; this Cup was offered in 1946 by the Association of Growers of the New Varieties of Hops; (3) the Hop Merchants' Association's Cup, offered in 1949 by this Association for New Varieties certified as showing resistance to *Verticillium* Wilt.

The ninth Competition was held, under the auspices of the Institute of Brewing, in the showrooms of Messrs. Wigan, Richardson and Co., 15 Southwark Street, London, on 21st and 22nd January, 1953, the Judges being Mr. J. Jackson, Mr. F. C. Lovett and Lieut.-Col. F. N. Richardson.* A List of Entries is given in Tables 1-3, together with the analyses which were carried out at Wye College, between 10th and 20th December, 1952, by Mr. G. A. Watson, M.Sc., under the direction of Dr. A. H. Burgess.

The Brewers' Cup was awarded to Furnace Farms, Ltd. for a sample of Bullion Hop (Q43), with an analysis of 9·07 per cent. α acid and 13·06 per cent. β resins. The Second Place was given to Brewer's Gold (C9*a*) grown by Mr. E. M. Gorst; this sample gave 9·35 per cent. α acid, the highest in the Exhibition. The Third Place was given to Bullion Hop, grown by Mr. J. A. Worley, with an analysis of 7·81 per cent. α acid and 11·56 per cent. β resins.

It is puzzling to find that a sample of Early Promise (X35) was placed in this Class.

The Growers' Cup was awarded to Mr. J. Nott for a sample of Northern Brewer (WFB135), with the excellent analysis of 9·02 per cent. α acid and 10·88 per cent. β resins, the highest for this Variety. All the samples of Northern Brewer exhibited gave high analyses,

* It has been announced that the Exhibition will be shown also at the School of Technology, at Manchester, on 5th and 6th February, 1953, and at the North British Station Hotel, Edinburgh, on 5th and 6th March, 1953.

as did likewise the sample of John Ford Hop (WFA90). For these two Varieties, now getting well known by brewers in this country and abroad for their uniformly high preservative properties (P.V.), the demand much exceeds the supply; the acreage planted is at present small, but it is hoped, now that the Hops Marketing Board has raised the valuation of both to the Golding class, that it will soon be increased. The Second Place was given to a sample of Sunshine Hop (V94) grown by J. F. Bomford, Ltd. with an analysis of 6·19 per cent. of α acid; another sample of this Variety gave 7·51 per cent. Sunshine Hop has all the characteristics required for successful machine-picking. The Third Place was given to Early Promise (X35), grown by Messrs. Wm. Skinner & Son, with an analysis of 6·31 per cent. α acid. Other samples of this Variety gave analyses as high as 8·23, 7·71 and 6·74 per cent. α acid. Early Promise is a valuable Variety, being of easy cultivation with marked resistance to Downy Mildew, particularly as regards the cones; and when the soil and "local climate" are suitable it is richer in preservative properties than the Fuggle. It is noteworthy that all the five growths of Pride of Kent (170*a*) exhibited, from different districts in Kent with very different soils, gave excellent analyses, not only in the α acid content, but were outstandingly high in the percentage of β resins; this last feature is characteristic of the Variety.

It is puzzling, again, to find that two samples of Brewer's Gold (C9*a*) were placed in this Class.

The Cup for Varieties resistant to *Verticillium* Wilt was awarded to T. R. Boorman & Co. for a sample of Keyworth's Midseason (OR55). The excellent number of entries for this Class comprised eight samples of OR55, with analyses ranging from 7·98 to 6·47 per cent. α acid, and one sample of "Bramling Cross" (OT48), with 7·80 per cent.

TABLE I

ENTRIES FOR BREWERS' CHALLENGE CUP, 1952.

Variety and Grower	Parish	Hops moisture-free	
		α acid %	β fraction %
Brewer's Gold (C9*a*)			
†E. M. Gorst	Brenchley, Kent	9·35	10·23
A. S. Mercer	Tonbridge, Kent	8·59	10·33
E. L. Worsfold	East Sutton, Kent	8·32	10·70
H. Veall	Capel, Kent	8·27	10·45
E. E. Taylor	Kingsdown, Kent	8·15	10·59
W. L. Hubble	Hunton, Kent	8·14	11·30
A. & K. J. Amos	Wye, Kent	7·99	10·11
Wm. Skinner & Son	East Sutton, Kent	7·97	10·26
J. A. Worley	Chart Sutton, Kent	7·89	9·87
R. D. Wickham	Brenchley, Kent	7·70	10·39
A. Guinness, Son & Co., Ltd.	Teynham, Kent	7·68	11·35
A. Guinness, Son & Co., Ltd.	Braces Leigh, Worcs.	7·22	9·50
Wm. Alexander, Ltd. ..	Eynsford, Kent	5·74	6·87
Bullion Hop (Q43)			
*Furnace Farms, Ltd. ..	Lamberhurst, Kent	9·07	13·06
E. M. Gorst	Brenchley, Kent	8·48	10·73
Little Fowle Hall	Yalding, Kent	8·42	6·58
Wm. Chambers & Sons ..	Langley, Kent	8·24	9·78
‡J. A. Worley	Chart Sutton, Kent	7·81	11·56
A. Guinness, Son & Co., Ltd.	Teynham, Kent	7·74	11·46
Blackmoor Estates	Selborne, Hants	7·61	11·86
T. E. Wimshurst	Brenchley, Kent	7·56	10·88
Wm. Alexander, Ltd. ..	Eynsford, Kent	7·53	11·16
A. Guinness, Son & Co., Ltd.	Braces Leigh, Worcs.	7·47	11·08
J. Nott	Tenbury, Worcs.	7·32	11·23
J. F. Bomford, Ltd.	Fladbury, Worcs.	6·90	11·62
R. B. Wickham	Brenchley, Kent	6·15	12·23
Early Promise (X35)			
J. F. Bomford, Ltd. ..	Fladbury, Worcs.	8·23	9·95
Malling Midseason (BB28)			
Little Fowle Hall	Yalding, Kent	7·32	13·16
J. F. Bomford, Ltd.	Fladbury, Worcs.	5·60	9·89
D1 (*East Malling Research Station*)			
Brian H. Day, Ltd.	Marden, Kent	6·60	5·98
C2 (*East Malling Research Station*)			
Brian H. Day, Ltd.	Marden, Kent	4·18	8·85

* Awarded Cup. † Placed Second. ‡ Placed Third.

TABLE 2.

ENTRIES FOR GROWERS' CHALLENGE CUP, 1952.

Variety and Grower	Parish	Hops moisture-free	
		α acid %	β fraction %
Northern Brewer (WFB135)			
*J. Nott	Tenbury, Worcs.	9·02	10·88
A. & K. J. Amos	Wye, Kent	8·69	9·74
H. Veall	Capel, Kent	8·45	8·89
J. A. Worley	Chart Sutton, Kent	8·36	9·98
W. D. Hukins	Tenterden, Kent	7·95	9·18
Brewer's Gold (C9*a*)			
Wm. Chambers & Sons ..	Swanscombe, Kent	8·88	9·87
Wm. Chambers & Sons ..	Sevenoaks, Kent	7·08	5·18
John Ford Hop (WFA90)			
T. E. Wimshurst	Brenchley, Kent	8·77	10·31
Pride of Kent (170*a*)			
H. Veall	Capel, Kent	8·04	14·36
Wm. Chambers & Sons ..	Southfleet, Kent	7·71	11·82
Wm. Chambers & Sons ..	Sevenoaks, Kent	7·41	12·96
A. & K. J. Amos	Wye, Kent	7·25	12·05
T. E. Wimshurst	Brenchley, Kent	7·07	11·79
Early Promise (X35)			
Little Fowle Hall	Yalding, Kent	7·71	8·27
Wm. Chambers & Sons ..	Southfleet, Kent	6·84	7·71
Wm. Chambers & Sons ..	Langley, Kent	6·74	6·49
‡Wm. Skinner & Son ..	East Sutton, Kent	6·31	8·23
Wm. Chambers & Sons ..	Sevenoaks, Kent	6·07	8·99
Wm. Chambers & Sons ..	Hunton, Kent	5·51	9·38
R. D. Wickham	Brenchley, Kent	4·38	13·03
Sunshine Hop (V94)			
Wm. Chambers & Sons ..	Southfleet, Kent	7·51	9·75
†J. F. Bomford, Ltd.	Fladbury, Worcs.	6·19	8·41
Bramling Cross (OT48)			
Brian H. Day, Ltd.	Marden, Kent	7·47	9·17
OF27			
J. Nott	Tenbury, Worcs.	6·71	8·24
College Cluster (N15 *bis*)			
T. E. Wimshurst	Brenchley, Kent	5·72	7·72

* Awarded Cup. † Placed Second. ‡ Placed Third.

TABLE 3

ENTRIES FOR HOP MERCHANTS' ASSOCIATION'S CHALLENGE CUP, 1952.

Variety and Grower	Parish	Hops moisture-free	
		α acid %	β fraction %
Keyworth's Midseason (OR55)			
W. L. Hubble	Hunton, Kent	7·98	8·82
*T. R. Boorman & Co. ..	Lamberhurst, Kent	7·87	8·78
E. M. Gorst	Brenchley, Kent	7·76	8·97
H. J. Highwood, Ltd. ..	Horsmonden, Kent	7·38	8·13
†G. A. & S. G. Calcutt ..	Cranbrook, Kent	7·26	8·89
‡D. H. J. Britcher	Yalding, Kent	7·09	9·87
Messrs. Whitbread & Co.,Ltd.	Paddock Wood, Kent	6·70	11·73
Spelmonden Estates ..	Horsmonden, Kent	6·47	8·75
Bramling Cross (OT48)			
Brian H. Day, Ltd.	Marden, Kent	7·80	9·75
D1 (*East Malling Research Station*)			
Brian H. Day, Ltd.	Marden, Kent	6·51	7·09
C2 (*East Malling Research Station*)			
Brian H. Day, Ltd.	Marden, Kent	4·25	13·61

* Awarded Cup. † Placed Second. ‡ Placed Third.

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